Stock Type Trial Series within the Boreal Forest of the Northeast Region – 1987 to 1997

NEST Information Report IR-027
August 2004

by
Stan Vasiliauskas
John Parton
John Gillham

Ontario

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INTRODUCTION

BACKGROUND

During the 1980s, the Ontario Ministry of Natural Resources planted 65 million container and bareroot trees annually in the Northern Region (now part of the Northeast Region). Black spruce (*Picea mariana* (Mill.) B.S.P.) and jack pine (*Pinus banksiana* Lamb.) were the principal species used for this regeneration effort. At this same time, there was a shift from bareroot stock to container stock and from Ministry-owned nurseries to private growers. The Northern Forest Development Group (now Northeast Science and Information), of the Ontario Ministry of Natural Resources recognized that there were gaps in information on seedling stock management. It hosted the 1986 "Fitness for Purpose" workshop in Timmins to assess grower and user needs around stock standards and early plantation performance. Forty field trials (20 for each of the principal species) were established between 1987 and 1991 to help define stock standards and to evaluate early plantation growth. Trials were followed for five years for jack pine and seven years for black spruce with final measurements occurring in 1997.

The mid-90s witnessed the evolution of a new business relationship between the OMNR and the forest industry, with the forest industry accepting increased responsibility and accountability for the management and renewal of Ontario's Crown forests. This change in traditional roles significantly altered the context for this trial series, and for a time, reduced the level of effort and investment in this project. However, it was realized that many of the information needs that drove the original trial series are still relevant today (trees are still being planted!), and that some emerging information needs could be addressed by information garnered from this work.

This report presents a synthesis of results from these trials and provides descriptions of the sites, trial methodology and general trends in relation to stock type.

OBJECTIVES

The primary objectives of these trials were to determine the following:

- What stock type provides the best 'value for our money'? Value for our money is defined as the most economical black spruce and jack pine stock type planted operationally on a given site that will consistently obtain the following minimum standards:
    - Jack pine: 90 percent survival and **free-to-grow* status at the end of the fifth growing season
    - Black spruce: 85 percent survival and free-to-grow status at the end of the seventh growing season

  These minimum standards reflect long-term performance measures observed in the Northeast Region with traditional bareroot growing stock.
- Are stock morphological/physiological parameters reliable indicators of subsequent performance (defined as the ability of a stock type to maintain a predefined level of survival and growth) over a range of sites, provided a routine tending regime occurs?

Stock types are morphologically and/or physiologically unique and will vary in their growth characteristics in the field. Stock types also interact with site features, (e.g. Ecosites) such that a given stock type may not be 'best' across all sites.

* Note: Free-to-grow is defined as a tree at least one metre tall and free of overtopping competition.

Stock Types

Container stock can be grown in a variety of container types and sizes. In these trials, most of the container stock types were grown in Japanese FH408 paperpots (volume 83 cm^3, Paterson 1991), semi-porous containers that are planted with the seedling. They are no longer produced in Ontario due to concerns about root deformation caused by slow pot deterioration after planting (Johnson *et al.* 1996). The two other container types used in some trials were jiffypot 144 and multipot 645 (volume 105 cm^3, Paterson 1991). Jiffypots are soft-walled containers that have more pores and break down faster than paperpots. Jiffypots are also planted with the seedling. Multipots are rigid-walled containers where the seedling is removed with a root and soil plug for planting.

Container stock types are distinguished by the growing regime used in the greenhouse. Current stock are the smallest and cheapest stock type in present use. Growers that have heated greenhouses (27°C) can sow black spruce seeds in January, and jack pine seeds in February. Seedlings are actively grown for about 13 weeks after germination and then moved out of the greenhouse to promote bud development and lignification. These seedlings are planted in June and July of the same year, and usually do not grow until the next season. Current crops that are not planted the first year can be held by the grower and planted the following season. These seedlings are classified as current-overwinter stock.

Overwinter stock can be separated into single and double crop and by normal day and short day growing regimes. Single and double crop refers to whether the grower produces one or two crops of seedlings per year. Normal day and short day refers to the method of hardening off used by the grower prior to moving the seedlings outside for the winter.

Growers without heated greenhouses produce overwinter-single crop stock. Crops are sown in mid to late April, and seedlings are actively grown for 15 weeks. Once the trees have reached the desired size, bud set is initiated by limiting one or more growth factors. If bud set is delayed, trees can become too large and are at greater risk of having disease problems (Millson 1988).

Growers that produce overwinter-double crop stock start this crop in early June after the current stock is moved out. Seedlings are actively grown for nine to ten weeks until the last week of August, and are then hardened off by moving the seedlings out of the greenhouse and stored in the holding area for planting the following spring in May and early June.

Overwinter stock has to be adequately conditioned before moving outside; otherwise they can suffer frost damage to the shoots and roots. One of the methods used to condition (harden-off) seedlings is called the short-day treatment. Seedlings are hardened-off in the greenhouse by limiting the photoperiod to eight hours and covering the seedlings the rest of the time with a

blackout curtain. Seedlings set bud much faster under these conditions allowing more time for hardening off, compared to seedlings hardened off under normal day length. The short-day method produces seedlings with larger buds that grow for a longer period in the first season after planting. This stock type is referred to as overwinter-short day. A second method of hardening-off seedlings is by using normal day length and limiting seedling moisture and/or nutrients. Seedlings hardened-off in this manner are referred to as overwinter-normal day.

Bareroot was the traditional stock type used for decades in Ontario. Bareroot stock are usually identified by the length of time that the seedling grows in the greenhouse, nursery seed bed, transplant bed, or any combination of these (e.g. greenhouse and transplant bed). The codes commonly used to define bareroot stock are in the format $a + b$ where a is the location (greenhouse = G) or number of seasons in the nursery seed bed and b is the number of seasons in the transplant bed. These trials used 2 + 0 bareroot stock for jack pine for the first two seasons, before bareroot jack pine were discontinued. This stock was sown in the nursery bed and grown for two full seasons before fall lifting, cold storage and planting the following spring.

Three different black spruce bareroot stock types were used in these trials: small, medium and large. Small bareroot stock (1.5 + 1.5) are sown outdoors and grown for one and a half seasons in the seed bed. They are then moved into the transplant bed at the nursery in the middle of the second season, and lifted at the end of the third season for shipping. Medium bareroot (G + 1.5) stock are in the greenhouse for the first season, then transplanted into the nursery transplant bed in the middle of the first growing season and left there for lifting at the end of the second growing season. Large bareroot (G + 2) stock are started in the greenhouse at the same time as the medium bareroot, then moved to the transplant bed at the start of the second growing season, and grown there for two full seasons before lifting.

Seedling Size, Cost and Plantation Growth

Seedling production costs can vary widely. Container stock is generally cheaper than bareroot, as it requires less handling and time to produce. Within container stock types, current crops are the cheapest, followed by overwinter stock and two-year-old multipot stock. Seedling cost, however, is only one consideration. Seedling size will also vary between the stock types. Generally, current, overwinter and current-overwinter stocks are smaller at outplanting than bareroot or multipot stock (Millson 1988).

Cost and size have to be balanced against growth after outplanting and competition levels on the site. Stock performance after outplanting is directly related to initial size, provided that the physiological conditions are similar. Larger stock can outperform smaller stock and outgrow most competition. Smaller stock types are normally one to two years behind in height growth. Because of this height difference, they are more likely to be suppressed on competitive sites and either take longer to achieve free-to-grow status or die (Racey *et al.* 1989, Paterson and Maki 1994, Barber 1989).

Consequently, stock type needs to be matched to site conditions. On non-competitive sites, smaller, cheaper stock can be used for planting, usually with minimal site preparation. Competitive sites, however, are more difficult and more costly to regenerate. These sites may require some form of site preparation before planting to temporarily reduce competing vegetation. Tending may also be required after planting to help the seedlings reach free-to-grow

status. On these sites, larger stock should be used (Racey *et al.* 1989, Pitt *et al.* 1999, Dobbs 1976, Scarratt 1982, Wood and Campbell 1988). Using larger stock can lower site preparation costs, avoid some of the problems with heavy site preparation (nutrient loss, invasion by grasses and sedges, frost heaving, etc.), and may even reduce tending costs. These additional costs must be weighed, along with nursery costs, as part of the total regeneration expense for a site.

METHODS

Forty separate trials (20 for black spruce, 20 for jack pine) were established in the Northeast Region between 1987 and 1991. There were two separate data collection components for each trial. For assessing morphological characteristics of each stock type prior to planting, 25 trees were randomly selected and evaluated at the Swastika tree nursery west of Kirkland Lake. Morphological characteristics and the measurement standards include:

- shoot height (0.1 cm)
- root collar diameter (0.1 mm)
- shoot/diameter ratio
- root dry weight (0.1 g)
- shoot dry weight (0.1 g)
- total dry weight (0.1 g)
- root area index (0.1 cm^2)
- shoot/root ratio

The second component to the data collection was the District field trial. At each trial location, site information collected included:

- previous stand composition
- logging method
- site conditions after logging
- site preparation
- weather prior, during and after planting
- geographic location
- parent material
- slope
- soil moisture, drainage and texture
- ecosite

The following assumptions have been made:

- there will be some seedling mortality due to nursery production, handling and field planting
- there will be average weather conditions at planting time and over the trial period
- tending will only come as part of a regular operational practice; no special care will be given to trials and all stock types will be treated equally with tending on a specific trial site
- all stock is to be planted according to contract specifications
- all stock will be randomly selected for the trial from producing growers
- a stock type is defined as the specific characteristic by which the stock is ordered and supplied to the end users:
    - bareroot: by size class (small, medium, large)
    - container: by age class (current, overwintered, current-overwintered, one year old or two-year-old multipot)

Field Design

Trials were established across a range of OMNR Districts, ecoregions (3E and 4E) and Ecosites (2, 3, 4, 5f, 6c, 6m, 6f, 7c, 7m, 7f, 8, 9p, 9r and 12). Sites selected represented typical planting sites for each OMNR District and used the most common local form of site preparation in use at that time. Site selection, trial establishment, subsequent measurements and maintenance were done by District staff.

Trials were established as a randomized complete block design. Each trial used only jack pine or black spruce, and there was no intermixing of species in a trial. Trials were placed in the field to maximize site homogeneity. If site gradients were unavoidable, blocks were placed to minimize within-block variation.

Blocks were laid out prior to planting at each site. Corners were marked with wooden 10 cm by 10 cm by 2.4 m posts and stock type plots were marked with 5 cm by 5 cm by 1.2 m posts. Stock type plots were randomized within each block. Trees were planted at 1.8 m by 1.8 m spacing and marked individually with steel pins and aluminum tags giving the block, stock and tree number. If a naturally established tree was close enough to the planted tree to be confused with it, then the naturally established tree was removed.

Photo location posts were put into one randomly selected block to mark locations for photographing two individuals of each stock type at each remeasurement. The posts were placed at the start of the middle row for each stock type plot. The top of the post was 1.2 m above the ground, and the post was 2 m away from the first seedling. The seedlings photographed were numbers 11 and 13, or the nearest living seedlings.

There were two separate planting times for each trial. Overwintered container stock and bareroot stock were planted first, and current container stock planted later in the season. This presented a problem with planting contractors, as the planters that did the first part of the trial

were usually not available to do the second part. In most trials, District staff planted the current container stock.

Field design changed during the course of the study. Trials established between 1987 and 1989 had four blocks, while trials established in 1990 and 1991 had five. Trials established in 1987 and 1988 had 100 seedlings of each stock type planted per block. This was reduced to 25 seedlings after 1988. Data collection was reduced to the first 25 trees from the original 100 trees for each stock type and block combination from the 1987 and 1988 trials, and only the data for these trees was saved from the earlier measurements. The number of stock types tested decreased over the course of the study. Details on each stock type by species and year are given in Appendices 1a to 1l. A total of ten different stock type categories were evaluated for black spruce and five for jack pine (Table 1).

Table 1. Summary of Stock Type Categories and Number of Examples for Each Stock Type Used in the Trials by Year and Species. All Container Stock Used Japanese FH 408 Paperpots Unless Indicated Otherwise.

Stock Type Category	Year				
Jack Pine	1987	1988	1989	1990	1991
Current	6	6	3	2	2
Overwinter	9	10	7	2	2
Current - jiffypot	-	-	-	2	2
Overwinter - jiffypot	-	-	-	2	2
Bareroot	4	4	-	-	-
Total	19	20	10	8	8
Black Spruce	1987	1988	1989	1990	1991
Current	5	5	1	1	1
Overwinter - normal day	10	9	4	1	1
Overwinter - short day	1	2	5	1	1
Current/overwinter	-	-	-	1	1
2 year multipot	-	1	1	1	1
1 year multipot	-	-	-	-	1
Bareroot - small	-	-	1	1	1
Bareroot - medium	1	1	1	1	1
Bareroot - large	1	2	1	1	1
Jiffypot	-	-	1	-	-
Total	18	20	15	8	9

Data Collection

Seedling survival and health condition were assessed three weeks after planting of the current stock. Seedling height, condition and survival (Table 2) were remeasured in the fall of the first, second, third and fifth growing seasons. Black spruce had an additional measurement in the fall of the seventh growing season. Heights were measured to the nearest 0.5 cm. Drooping leaders and leaning trees were straightened out against the ruler. Diameters to the nearest 0.1 mm were measured at 30 cm above the ground on the final survey. Starting with the 1988 trials, survival assessments were made as early as possible in the spring of the second growing season. Competition assessments were done at the end of the second growing season. Dataloggers were used for electronic data collection.

Table 2. Seedling Survival and Condition Codes Used in All Trials.

Code	Condition
1	Dead
-1	Missing
10	Healthy with terminal leader
11	Discoloured foliage and with terminal leader
12	Physical and/or abiotic damage, and with terminal leader
13	Biotic damage and with terminal leader
14	Other damage or condition, and with terminal leader
20	Healthy with lateral leader
21	Discoloured foliage and with lateral leader
22	Physical and/or abiotic damage, and with lateral leader
24	Other damage or condition, and with lateral leader

Data Analyses

Analysis of variance (ANOVA) was used to determine the effect of stock type on each of the stock performance variables. Orthogonal contrasts were used to compare specific stock types to determine if significant differences existed for any of these variables. Statistical packages used in analyses included STATGRAPHICS® and SYSTAT®. Stock performance variables were calculated using the following equations:

Mean height = (thh + thu) / (nh + nu)

Mean diameter = (tdh + thu) / (nh + nu)

Current annual height increment = (thi + tui) / (nh + nu)

Survival = (n live / (n-missing))*100

Performance index = (thh + thu) / (n – (missing + damaged trees))

Relative growth rate = (ln(mh(T2) – ln(mh T1)) / (T2–T1)

n	=	number of stems
nh	=	number of healthy stems
nu	=	number of unhealthy stems
thh	=	total height of healthy stems
thu	=	total height of unhealthy stems
tdh	=	total diameter of healthy stems
tdu	=	total diameter of unhealthy stems
thi	=	total height increment of healthy stems
tui	=	total height increment of unhealthy stems
mh	=	mean height
T1	=	time 1
T2	=	time 2
ln	=	natural logarithm

Trees with biotic (e.g. weevil), or abiotic (e.g. frost) damage (condition codes 12, 13, 14, 22 and 24) were only used in percent survival analyses. All other stems (condition codes 10, 11, 20, 21) were used in all analyses. Current annual height increment (CAHI) was analysed based on the mean leader growth for the last two years of growth, and was calculated by subtracting the second last height measurement from the last height measurement and dividing by two. Performance index was used to incorporate survival into plantation performance. For example, if two stock types have similar heights, but different survival rates, the stock type with the higher survival rate would have a higher performance index.

Trial Location, Establishment and Maintenance - Jack Pine

1987 Trials

Chapleau Trial #1 – The first Chapleau trial is in Copperfield Township, 1 km west of Copperfield Lake (*Figure 1). The site is flat to gently rolling with fresh silty sands and some rocks. The previous stand was a $Bw_5Pj_2Po_2Sw_1$, 80 years old, 13 m tall, 0.6 stocking and site class 2 (Ecosite 3). The area was clearcut in 1985 with site preparation the following year using a C&H plough. Overwinter and bareroot stock were planted between May 31 and June 2, 1987. The weather was warm (25°C to 28°C highs) with heavy rain on the first day. Some of the overwinter stock types had brown tops. No date was recorded for planting of current stock.

Chapleau Trial #2 – The second Chapleau trial is in Strom Township, about 45 km southeast of Chapleau, and just west of Little Wenebegon Lake (Figure 1). The previous stand was a Pj_9Sb_1 (Ecosite 2). The site was flat with dry to fresh, deep, fine sandy soils. The area was clearcut in 1984 followed by mechanical site preparation in 1985 with a Bräcke cultivator. Overwinter and bareroot stock were planted on May 29 to 30, 1987, under sunny and warm (23°C to 29°C) conditions. As in the other Chapleau site, some overwinter stock types had brown tops. No date was recorded for planting of current stock.

Timmins – The Timmins trial is in the extreme southwest corner of Kenogaming Township, about 1 km east of Wye Lake (Figure 1). The site is flat to gently rolling with numerous stones and boulders in a medium sand. The previous stand was $Po_6Pj_2Sb_1Sw_1$, 72 years old, 24 m tall, 0.8 stocking and site class 2 (Ecosite 3). The area was clearcut in the summer of 1985 and mechanically site prepared using a Donaren power disc trencher and prescribed burned the following year. Overwinter and bareroot stock were planted between May 22 and 24, 1987, under cool (8°C to 10°C) conditions with showers the first two days, but warm (25°C) and sunny the last day. Some overwinter stock types had brown tops. Current stock was planted on June 25 and 26, 1987 under sunny and warm conditions with an overnight shower.

The area was aerially sprayed with glyphosate for competition control on September 10, 1988.

Kirkland Lake – The Kirkland Lake trial is located in Cairo Township, about 1 km east of Highway 65 on the Souci Lake Road (Figure 1). The site is on a flat, glaciofluvial outwash plain with rapidly drained, dry, deep medium sands with gravel and cobble pockets (Ecosite 2). The previous stand was Pj_{10}, 52 years old, 14 m tall, 0.6 stocking and site class 2. The area was conventionally clearcut in 1985 followed by mechanical site preparation with a Bräcke cultivator the same season. Planting conditions were warm to hot and mainly sunny. Some overwinter stock types had brown tops.

*Note: Specific site location maps and coordinates are available on file at the Northeast Science and Information office in South Porcupine.

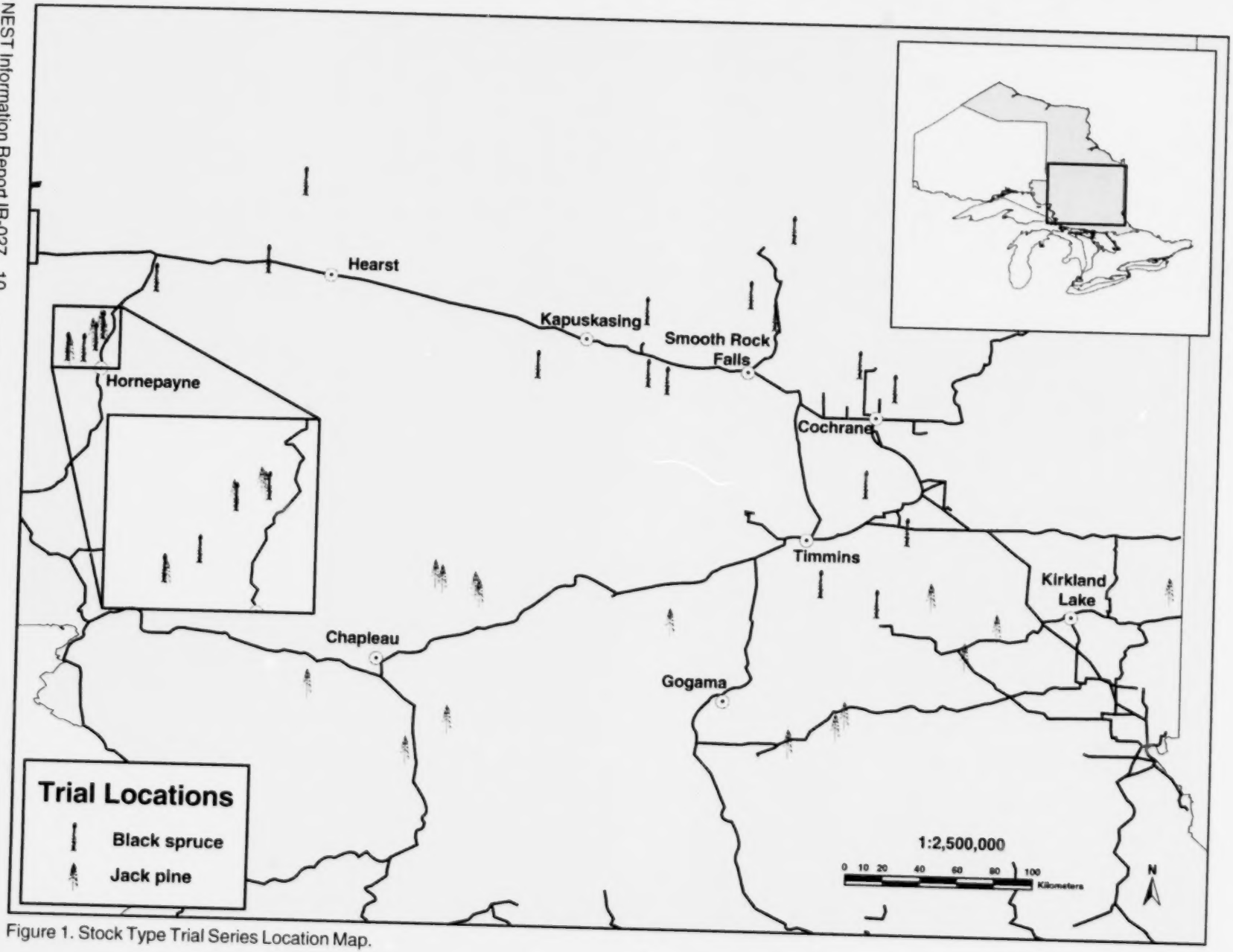

Figure 1. Stock Type Trial Series Location Map.

1988 Trials

Chapleau Trial #1 – The first Chapleau trial is in Copperfield Township, about 1 km east of Copperfield Lake (Figure 1). The previous stand was a Bw B-S, site class 1 (Ecosite 3). The site is gently rolling. The area was clearcut in 1984, followed by site preparation involving crushing the vegetation, chemical spraying with 2,4-D and prescribed burning in 1987. Overwintered and bareroot stock were planted on May 24 to 26, 1988. Current stock was planted on June 21, 1988. No tending was done on this site.

Chapleau Trial #2 – The second Chapleau trial is in Hutcheon Township, about 1 km south of Wolotka Lake (Figure 1). The previous stand was Pj_9Po_1, 72 years old, 23 m tall, 1.1 stocking and site class 1 (Ecosite 2). The site is a flat to gently rolling outwash plain with fine to medium sands with some stoniness, of moderate depth and a dry/fresh moisture regime. The site was clearcut in 1987 and followed by mechanical site preparation with a TTS disc trencher in summer 1987. Overwintered and bareroot stock were planted on May 25 and 26, 1988. Current stock was planted on June 22, 1988. No tending was done on this site.

Gogama – The Gogama trial is in Garibaldi Township, about 35 km east of Highway 144 and about 600 m north of Highway 560, adjacent to the Garibaldi seed production area (Figure 1). The site is a flat, glaciofluvial outwash plain. The soil is a thin veneer of very fine sandy loam and silty very fine sand overlying gravelly loamy coarse sand and gravelly coarse to medium sand (Ecosite 2). Moisture regime is moderately dry with rapid to very rapid drainage. The site was clearcut in 1986 and followed by mechanical site preparation with a TTS disc trencher in October 1987. Overwintered and bareroot stock were planted on May 17 and 18, 1988. Current stock was planted on June 29, 1988. The final assessment in 1992 indicated that competition was not a problem. However, there was a substantial amount of damage to the crop trees from *Armillaria mellea* root rot and also leader damage from white pine weevil.

Hearst – The Hearst District trial is in Elgie Township, about 10 km southwest of Nagagamisis Provincial Park (Figure 1). The previous stand was $Sb_5Po_3Sw_1Bw_1$, 100 years old, 15 m tall, 0.8 stocking and site class 2 (Ecosite 3). The site is a gently rolling till plain with pockets of coarse sand mixed with silt loam and medium to very fine sand. The area had been sprayed for jack pine budworm (*Choristoneura pinus pinus* Freeman) control in 1985. The area was clearcut in 1986, followed by mechanical site preparation with bulldozers and angle blades in 1987, which removed most of the surface organic layers. Overwinter and bareroot stock were planted on May 17 and 18, 1988 under dry and warm (20°C) conditions. Current stock was planted on June 22, 1988 under warm (16°C) and damp conditions with 3.2 mm rain. Tending with glyphosate in 1991 helped to control competition.

1989 Trials

Chapleau Trial #1, Paul Township – The Paul Township trial is about 75 km northeast of Chapleau and just east of the Nemegosenda River (Figure 1). The original stand was Pj_9Po_1, 70 years old, 20 m tall, 0.9 stocking and site class 1 (Ecosite 2). Soils are rapidly drained, fresh, shallow to moderately deep very fine sandy loams with some rock outcrops. The site is uneven, as blocks 1 and 2 were on a bedrock knob with shallow soil and the other two blocks were downslope of the knob in deeper soil. The stand was cut in the winter of 1988 and site

prepared using a TTS disk trencher in the summer of 1988. Overwinter stock was planted on May 25, 1989 under cool, windy, partly cloudy conditions with some earlier rain. Current stock was planted on June 21, 1989 under hot, dry and windy conditions.

Chapleau Trial #2, Hutcheon Township – The Hutcheon Township trial is south of Chapleau, about 2 km southwest of Wolotka Lake and 0.5 km north of Bernier Township (Figure 1). The previous stand was a Pj_9Sb_1, 72 years old, 23 m tall, 1.1 stocking and site class 1 (Ecosite 2). Soils are deep, glaciofluvial, deposits composed of rapidly drained, dry to fresh, fine to medium sands with some stoniness. There is a gentle slope across the site. The area was clearcut in 1987 with site preparation using a TTS disk trencher the following summer. Overwinter stock was planted on May 27, 1989, under cool, windy and partly cloudy conditions with some rain. Current stock was planted on June 19, 1989 under hot, dry and windy conditions. At the time of planting there was a substantial amount of natural regeneration, most of which was removed in the trial area to avoid confusion with planted seedlings.

Kirkland Lake – The Kirkland Lake trial is in Michie Township, just south of McPhail Lake (Figure 1). The site is on an outwash plain, with fine to medium sands and a small percentage of gravel in the soil. Drainage is very rapid to rapid with moisture regime 0 to 1. The original stand was Pj_{10}, 53 years old, 16 m tall, 0.9 stocking and site class 2 (Ecosite 2). The site was full tree logged in 1988 followed by mechanical site preparation that fall with a Bräcke scarifier and skidder. Overwinter stock was planted on May 31, 1989, under cool (11°C to 13°C) and damp conditions. Current stock was planted on June 26, 1989 under warm (16°C to 26°C) conditions with 4.6 mm rain the previous three days. Competition was not a problem and no tending was done.

Gogama – The Gogama trial is in MacMurchy Township, about 2.1 km south of Highway 560, and 15.3 km east of Shiningtree (Figure 1). The previous stand was Po B-S, site class 2 (Ecosite 3). Soils are fresh, well drained silty very fine sands on a recessional moraine. The stand was clearcut using a Koehring feller buncher in 1987. Site preparation was with a root rake and windrowing. Overwinter stock was planted on May 17, 1989 under sunny and warm (27°C) conditions. Current stock was planted on June 22, 1989 under overcast, cool (19.5°C), and damp conditions with some rain. Competition was light on this site. Aerial spraying was done in 1991. Some pitch nodule maker (*Petrova albicapitana* (Busck)) was noted on the trees in 1991. The final assessments in 1993 indicated that competition was light with some willow and alder near the windrows. Some poplar stems were alive where they had been missed by the spray. There was a moderate to heavy infestation of jack pine tip beetle (*Conophthorus banksianae* McPherson) with numerous dead leaders and replacement by laterals.

Hearst – The Hearst trial is in the northeast corner of Lessard Township (now Wawa District) and is located 2.2 km west of Wicksteed Township boundary and 1.8 km south of the CNR line (Figure 1). The previous stand was a $Po_5Sb_2Sw_2Bw_1$, 100 years old, 26 m tall, 0.7 stocking and site class 2 (Ecosite 7m). Soils are variable, ranging from fresh to moist, coarse sand to sandy loam and loam. The area was cut in 1987 and 1988 and site prepared using straight blade bulldozers and corridors.

Overwinter stock was planted on May 23, 1989 under cool (10°C to 14°C), conditions with 3.2 mm of rain. Current stock was planted on June 16, 1989 under warm (11°C to 19°C) and dry conditions. Broadleaf herb and shrub competition was light to moderate. Chemical tending was done in 1992 using glyphosate. Poplar was heavily defoliated by forest tent caterpillars in spring 1992.

1990 Trials

Chapleau – The Chapleau trial is in the southwest corner of Lincoln Township, about 80 km northeast of Chapleau (Figure 1). The previous stand was a Pj_9Sb_1, 80 years old, 19 m tall and 1.0 stocking, site class 2 (Ecosite 2). The soil is a well drained, loamy coarse to loamy medium sand. The area was full tree harvested in 1988 and 1989, followed by mechanical site preparation with Donaren power disc trenchers in the fall of 1989. Regrowth consisted of blueberry (*Vaccinium* spp.) and some birch saplings. Overwinter stock was planted on May 28, 1990. Current stock was planted on June 21, 1990. Competition was minimal, with blueberry as the dominant shrub. No tending was done on this site.

Hearst – The Hearst trial is in Elgie Township, about eight km from Highway 531 on the West Elgie Road (Figure 1). The previous stand was a $Sb_5Po_3Sw_1Bw_1$, 100 years old, 15 m tall and 0.8 stocking, site class 2 (Ecosite 3). The soil is a well drained, loamy coarse to loamy medium sand. The area was logged in 1987 and 1988, followed by prescribed burning in 1989. Overwinter stock was planted on May 18, 1990, under cold (1°C) conditions with 6.2 mm rain. Current stock was planted on June 26, 1990, under cool (8°C) and wet conditions with 11.8 mm rain. The site had moderate competition from grass and broadleaf herbs during the course of the trial. No tending was done on this site.

Kirkland Lake – The Kirkland Lake trial is in Burt Township, Lot 12, Concession 1, about 3 km west of Burt Lake (Figure 1). The previous stand was Pj_9Sb_1 (Ecosite 2). The site is very gently sloping with rapid to well drained, loamy very fine sandy soils. The area was full tree logged in 1988, followed by Bräcke mechanical site preparation in 1989. Overwinter stock was planted on May 22, 1990 under sunny (15°C) and dry conditions. Current stock was planted on June 19, 1990 under cool (11°C) and dry conditions. The only change in the trial was with stock type 2 that was replaced by LAF9042-33-0-22 from MFT90B032-31-0-00.

Competition was mainly from grasses, sedges (*Carex* spp.), willow, blueberry, aspen, white birch and juneberry (*Amelanchier* spp.). However, this was not enough to limit jack pine growth, and no tending was done on this site.

Gogama – The Gogama trial is in MacMurchy Township, just west of Pat Lake (Figure 1). The site is an outwash plain, very rapidly drained, moderately fresh, gravelly sand. The previous stand was a $Po_5B_2Bw_2Sw_1$, 70 years old, 21 m tall and 0.7 stocking, site class 3 (Ecosite 3). The area was full tree logged, followed by mechanical site preparation using a root rake that removed most of the slash and surface humus layers. Overwinter stock was planted on May 23, 1990. Current stock was planted on June 18, 1990. May was dry with temperatures varying from 5°C to 25°C. June was unusually wet and temperatures varied from 9°C to 26°C.

Competition was light to moderate and no tending was done during the course of the trial.

Chapleau – The Chapleau trial is in Crepieul Township, about 2 km east of Nem Lake (Figure 1). The previous stand was a pure black spruce stand on flat terrain, 110 years old, 14 m tall, 0.9 stocking and site class 2 (Ecosite 4). The site was clearcut in 1990 and site prepared with a Donaren power disc trencher the same year. Overwintered stock was planted on May 29, 1991. Current stock was planted on June 27, 1991. Conditions were warm and dry during the plant. Competition was not a problem at any time and no tending was done.

Hearst – The Hearst trial is in Elgie Township, about 10 km west of Highway 11 and just off the West Elgie Road (Figure 1). The previous stand was a mixedwood conifer stand, $Sb_6B_3Ce_1$, on flat terrain, 130 years old, 15 m tall, 0.4 stocking and site class 2 (Ecosite 6m). The site was clearcut in 1989 and prescribe-burned in 1990. Overwinter stock was planted on May 22 and 23, 1991, under warm and dry (15°C to 28°C) conditions, followed by 15.8 mm of rain after planting. Current stock was planted on June 17, 1991, with warm (17°C to 28°C) and dry conditions.

Initial competition was moderate to heavy from grasses and some herbs and shrubs. Chemical tending with glyphosate on August 28, 1992 caused high tree mortality (52 percent) and damage (26 percent), as recorded the following year (1993). There was no sign of insect, frost or root disease, and most of the live trees were deformed. Stock type #2 suffered almost total mortality (93 percent).

Kirkland Lake – The Kirkland Lake trial is in Pontiac Township, about 45 km northeast of Kirkland Lake, about 3 km off the Pontiac-McVittie Road and just east of Sunrise Lake (Figure 1). The previous stand was a mixedwood, $Sw_3Bw_3Pj_2Po_2$, 79 years old, 12 m tall, 0.7 stocking and site class 2 (Ecosite 6m). The area is a morainal deposit, with silty loamy fine sands and pockets of sandy clay loams. Drainage borders between rapidly and moderately well drained, while moisture regime is between fresh and very fresh. The site was full tree harvested in 1989 and 1990, and most of the residual white birch was removed in fuelwood cuts. Site preparation was mechanical using a hydraulic TTS disc trencher in 1990. Overwintered stock was planted on May 17, 1991 under cold (-1°C to 9°C) and wet conditions with 3 mm rainfall during the plant. Current stock was planted on June 19, 1991 under warm (12°C to 29°C) and dry conditions.

Initial competition was heavy from aspen, bracken (*Pteridium aquilinum* (L.) Kuhn var. *latiusculum* (Desv.) L. Underw. ex A. Heller), grasses, sedges, broadleaf herbs, pin cherry (*Prunus pensylvanica* L. f.) and willow. The site was not tended during the course of the trial, but the jack pine did maintain good growth and high survival during this period. Some tree suppression was starting in the south part of the trial by 1995.

Trial Location, Establishment and Maintenance – Black Spruce

1987 Trials

Cochrane – The Cochrane trial is in Leitch Township, north of Cochrane and about 3 km north of Highway 579 and the Gardiner Ferry crossing (Figure 1). The previous stand was $Po_4Bw_3B_2Sw_1$, 80 years old, 21 m tall, 0.5 stocking and site class 3 (Ecosite 7f). The substrate is a moderately well-drained silty clay. The area was cut in the winter of 1985 and 1986 and shearbladed with a D8K tractor in March 1987. Bareroot and overwintered stock were planted on June 15 to16, 1987, under hot (> 22°C), windy conditions on June 15 and with windy and cool conditions on June 16. Current container stock were planted on June 26, 1987, with cool temperatures (15°C to 20°C) and light showers. The site was chemically tended in 1990 for competition control.

Hearst – The Hearst trial is in Stoddart Township, just west of the Valentine River and about 3 km north of Highway 11 (Figure 1). The previous stand was $Po_5B_4Bw_1$, 99 years old, 16 m tall, 0.6 stocking and site class 2 (Ecosites 6f and 7f). The soil is a well drained to poorly drained silty clay. The area was clearcut and tramped in 1985, followed by chemical site preparation and prescribed burning in 1986. Bareroot and overwintered stock were planted on June 13, 1987, under cool (7°C to 15°C) and dry conditions. Current container stock was planted on June 26, 1987, with cloudy and wet conditions (15°C) and 9.8 mm rain. Heavy slash impeded regular spacing efforts.

This was a very competitive site, with moderate to heavy regrowth of aspen (*Populus tremuloides* Michx.), grasses, herbs and shrubs. It was tended twice for competition control (fall 1988 and September 1993). Forest tent caterpillars heavily defoliated poplar saplings in 1991.

Timmins – The Timmins trial is in Cleaver Township, just 3 km east of Little Nighthawk Lake (Figure 1). The previous stand was $Sb_4Po_3Bw_2B_1$, 80 years old, 13 m tall, 0.6 stocking and site class 2 (Ecosite 6f). The area is relatively flat and the soil is a very moist, very poorly drained clay. The area was conventionally clearcut in winter 1986 and 1987. Mechanical site preparation was with a root rake on a D8, creating wide corridors between slash piles. Bareroot and overwintered stock were planted on May 22 to May 26, 1987. Temperatures were quite variable during this period (6°C to 25°C) with 16 mm of precipitation. No date was given for planting of current stock.

Aspen, alder (*Alnus incana* (L.) Moench ssp. *rugosa* (Du Roi) Clausen) and grass competition increased over the course of this trial. Site damage from logging created pools of standing water and promoted cattail (*Typha* spp.) growth in some parts of the site. Poor tree growth could be attributed to competition in some areas and to standing water and poor microsite conditions in other areas. Assessors recommended dropping block 1 from the trial due to heavy grass and sedge growth and standing water.

1988 Trials

Cochrane – The Cochrane trial is located in Homuth Township, just east of Homuth Lake and Highway 634 (Figure 1). The site is uniform and flat with minimal changes in topography within the trial location, and classified as Ecosite 8. The area was burned in a wildfire in 1977 that killed the original stand (FRI description not available). A regeneration survey in 1979 and aerial and ground surveys in 1987 indicated low post-fire conifer stocking. The site was shearbladed in preparation for planting in 1988. The trial was subsequently established as part of the reforestation effort for the area. The site is typical of most black spruce sites in Cochrane District that are site prepared with winter shearblading. The problem with this method is that sites that initially appear to be uniform may be less uniform after site preparation due to variations in soil textures and fertility.

Bareroot and overwinter stock were planted on May 31, 1988 under cool (20°C) and cloudy conditions with scattered showers and moderate winds. Current stock was planted on June 28 and 29, 1988, under very cool (6°C) and overcast conditions with moderate winds. The Energreen stock was considered spindly but still healthy compared to the other stock. The multipot stock from Swastika had the best form.

Hearst – Two trials were established in Hearst District in 1988. The first trial is located in Arnott Township, about 2 km southeast of Dodds Lake (Figure 1). The previous stand was $Sb_5Po_2\ Pj_2\ Bw_1$ for blocks 1, 2 and 3 (Ecosite 3), and Sb_{10} (Ecosite 4) for block 4. The substrate is a moist, imperfectly drained, very fine sand, on an outwash plain. The area was clearcut in the mid 1980s, with scattered aspen left standing. Chemical site preparation was followed by prescribed burning in 1987.

Bareroot and overwintered container stock were planted on May 19 and 20, 1988. Temperatures varied from 8°C to 27°C during the plant with no precipitation. The current stock was planted on June 22, 1988 under cool (13°C to 16°C) and moist conditions with 1.8 mm of rain during the plant.

Hand tending was done in 1992 on blocks one, three and four for release from poplar competition. Grass and herb competition was moderate in all blocks. Shrub competition was still heavy in block four and part of blocks one and three at the time of the last assessment in 1994.

The second trial is in Wicksteed Township (now Wawa District), northeast of Hornepayne and just west of Lennon Lake (Figure 1). The trial replicates are in two different stands. Blocks 1, 2 and 3 are in a former $Po_6Bw_2\ Sb_1\ Pj_1$ stand and block 4 is in a former $Sb_5Po_2\ Bw_2\ Ce_1$ stand. The site is not uniform, but is classed overall as a till (Ecosite 6c). Substrates in blocks 1, 2 and 3 are fine sands to silty fine sands, while block 4 is a poorly drained clay loam (Ecosite 9). Block 2 is well drained, and blocks 1 and 3 are poor to imperfectly drained.

The stand was clearcut in 1986 and mechanically site prepared using bulldozers with angle blades in 1987. Residual stems after logging include poplar, balsam fir (*Abies balsamea* (L.) Miller) and white birch (*Betula papyrifera* Marsh.) and rated as medium density. Bareroot and overwintered container stock were planted on May 24, 1988 under cool (0°C to 3°C) and dry

conditions. Current container stock was planted on June 23, 1988 under cool (6°C to 12°C) conditions. There was 3.2 mm of rain before the planting, none during the planting, and 5 mm after the planting.

Kapuskasing – The Kapuskasing trial is in Gurney Township, north of Remi Lake Provincial Park and just east of Maxwell Lake (Figure 1). The planting date and weather information is not available for this trial. The previous stand was a Sb_9L_1, 100 years old, 15 m tall and 0.7 stocking (Ecosite 12). Substrate is a wet, moderately decomposed organic soil with a thick surface fibric horizon. The area was clearcut in 1986, shearbladed in 1987, and planted in 1988. There was no initial competition, but within three years there was regrowth of small shrubs and heavy grass cover and invasion of water-filled depressions by cattails. Heavy seedling mortality was noted around these depressions. The area was sprayed with glyphosate in the summer of 1990, reducing competition. Grass competition caused some tree mortality. A late spring frost in 1992 damaged many stems less than 40 cm tall, but few stems over 40 cm tall (pers. obs. T. Schwan). Trees shaded by alder had no frost damage.

Timmins – The Timmins trial is in McArthur Township, about 2 km east of Papakomeka Lake (Figure 1). The area is gently rolling, with a fine sandy soil overlying a coarse sand with gravel, cobbles and stones. The soil is rapidly drained with a moderately fresh moisture regime (Ecosite 2). The previous stand was clearcut during the winter of 1986 and 1987. Site preparation was done with a power disc trencher in the spring of 1987. Bareroot and overwintered stock were planted on May 30 and 31, 1988. The conditions were hot and muggy on May 30 and warm with a slight breeze on May 31. The current stock was planted on July 5 under warm (27°C) and sunny conditions with some cloudy periods and a light breeze.

1989 Trials

Cochrane – The Cochrane trial is in Mewhinney Township, in the northwest corner of the township and just south of the Newpost River (Figure 1). The site is gently sloping to flat with some variation in soils. The clay soils are overlain with a fibric to humic organic layer. The previous stand was a conifer mixedwood stand, $Sb_6Po_2Pj_1Sw_1$, 110 years old, 18 m tall, 0.7 stocking and site class 2 (Ecosite 5f). The area was cut in 1981, but shearblading did not occur until February 1989 and windrowing with an angle blade on a D7 in May 1989. Two blocks were planted on May 25, 1989 under cold conditions with light precipitation. The other two blocks were planted on May 30 under warm and sunny conditions. The seedlings were healthy and just beginning to flush on May 30. Current stock was planted on June 21. Competition was low to moderate during the trial. Chemical tending was done in the summer of 1990.

Hearst – Two trials were established in Hearst District in 1989. The first trial is in Township 233, north of the Fushimi Road system (Figure 1). The previous stand was a conifer mixedwood stand, $Sw_4Po_3Sb_2B_1$, 135 years old, 19 m tall, 0.7 stocking and site class 1 (Ecosite 9r). The soil is a poorly drained, very moist silty clay. There was standing water in parts of the trial area during the plant. The area was cut in 1987–1988, followed by chemical site preparation with 2,4-D in June, tramping in July, and burning in October 1988.

Overwinter and bareroot stock were planted on May 24, 1989 under cool (8°C to 15°C) and wet conditions with 2.4 mm rain on the day of the plant. Current stock was planted on June 16 under warm (8°C to 21°C) and dry conditions.

Grass, herb and shrub competition became moderate to heavy after planting. Chemical tending with glyphosate in September 1992 reduced most of this competition. The final assessment found light competition from grasses and herbs.

The second trial is in Lessard Township (now Wawa District) and is located 2.2 km west of Wicksteed Township boundary and 1.8 km south of the ONR line (Figure 1). The previous stand was a mixedwood stand, $Po_5Sb_2Sw_2Bw_1$, 100 years old, 26 m tall, 0.7 stocking and site class 2 (Ecosite 7c). Soils vary from fresh and well drained, coarse sand to sandy loam and loam across the site. The area was cut in 1987 and 1988. Mechanical site preparation using straight blades on bulldozers created double width corridors.

Overwinter and bareroot stock were planted on May 23, 1989 under cool (10°C to 14°C) and wet conditions with 3.2 mm rain on the day of the plant. Current stock was planted on June 16, 1989 under warm (11°C to 19°C) and dry conditions.

Competition was light to moderate and mainly from herbs and shrubs. Forest tent caterpillars (*Malacosoma disstria* Hubner) heavily defoliated the site in 1991. Glyphosate was used for chemical tending in 1992.

Kapuskasing – The Kapuskasing trial is in Shackleton Township, about 8 km south of Highway 11 at Fauquier and just off the Shackleton Road (Figure 1). The site was logged in 1962 using chainsaws and skidders, and then left for natural regeneration. The 1986 FRI stand description is $Po_6B_2Bw_1Sb_1$, 25 years old, 11 m tall, 1.0 stocking and site class 2 (Ecosite 7f). The area was initially used to test the effectiveness of various chemicals in preparing a hardwood upland site for prescribed burning. Site preparation began in March 1987 with crushing the vegetation with a D8. Hexazinone was sprayed on the site on June 2, 1987, and prescribe burned on August 23, 1987. The burn effectively controlled vegetation with 100 percent coverage and duff reduction of 25 percent, despite low burning indices at the time of ignition.

Overwinter and bareroot stock were planted on May 29, 1989 under cool (3°C to 9°C) and cloudy conditions. Some seedlings from stock type 15 were considered in poor condition with roots partially dried out. Current stock was planted on June 22, 1989 under favourable weather conditions.

The intense site preparation effectively reduced competition on the site so that no subsequent tending was done during the course of the trial. Aspen and willow (*Salix* spp.) regrowth was patchy and not a concern. Seedling survival was excellent and growth was vigorous on this site. Frosts on June 22 and 30, 1992 caused many forked leaders. Some trees had white pine weevil (*Pissodes strobi* Peck) damage.

1990 Trials

Cochrane – The Cochrane trial is in Blount Township, on Blount Road, northeast of Cochrane (Figure 1). The previous stand was a pure black spruce stand, 150 years old, 15 m tall and 0.5 stocking (Ecosite 8). The flat and relatively uniform site has a very moist, imperfectly drained silty clay soil. The stand was logged in 1987, replanted unsuccessfully by Junior Rangers in 1988, and shearbladed in the winter of 1989 and 1990.

Bareroot and overwintered container stock were planted on May 23 and 24, 1990. Weather on May 23 was rainy and 13ºC, and on May 24 was clear and 20ºC. Current stock was planted on June 13, 1990 under sunny and warm (22ºC) conditions. Overall, the planting season was considered very wet. Stock was healthy and many bareroot trees had multiple leaders.

Initial competition was very light but increased by 1992 with heavy grass competition. Chemical tending in 1992 with glyphosate reduced this competition. The late spring frosts in 1992 damaged 45.2 percent of the trees, but they recovered by 1994.

Hearst – The Hearst trial is located in Elgie Township along the West Elgie Road (Figure 1). The 1974 FRI stand description was $Sb_5Po_3\ Sw_1\ Bw_1$, 100 years old, 15 m tall and 0.8 stocking, site class 2 (Ecosite 6f). It was clearcut in 1987 and 1988 and prescribe-burned in 1989.

Bareroot and overwintered container stock were planted on May 18, 1990 under wet (6.2 mm rain) and cold (0ºC) conditions. Current stock was planted on June 26, 1990, also under rainy (11.8 mm) and cold (7ºC to 8ºC) conditions.

Competition was moderate during the trial and primarily from grasses and herbaceous plants, and no tending was done.

Kapuskasing – The Kapuskasing trial is in Nansen Township, southeast of Kapuskasing (Figure 1). The location was 10 km south of Highway 11 off the Chain of Lakes Road, and 6.2 km east of this road on the Nansen forest access road. The previous stand was a $Po_6Sb_2\ B_1\ Ce_1$, 70 years old, 20 m tall and 0.7 stocking, site class 3. The Ecosite was 7f, and part of block 4 was Ecosite 12. The stand was full tree harvested with a feller-buncher in the winter of 1989–1990. Site preparation was done the same winter with a Rome K/G shearblade on a D8K tractor.

Bareroot and overwintered container stock were planted on May 25, 1990 under sunny and warm (19ºC) conditions. Subsequent cold weather with snow and some frost on May 28, June 2, 3 and 4 damaged many trees and they took several years to recover, especially the bareroot stock. Initial competition was severe from dense poplar sprouting (many sprouts over 1 m tall) in parts of the trial. Aerial spraying with glyphosate on August 7, 1991 reduced this competition and limited it to herbaceous species.

Timmins – The Timmins trial is in Little Township, along the Ice Chest Lake Road and about 3 km north of Nerandeau Lake (Figure 1). The site is a relatively flat, moderately moist, imperfectly drained, coarse to medium sandy soil (Ecosite 4) dominated by black spruce. The stand was clearcut using a feller buncher in 1989 followed by mechanical site preparation using a Bräcke Cultivator in November of the same year. Bareroot and overwinter stock were planted on May 16 and 17, 1990 under cool (10°C to 11°C) and wet conditions. Current stock was planted on June 15, 1990 under cool (8°C to 17°C) and dry conditions.

Initial competition was from herbaceous species and light aspen and shrub regrowth. The last survey noted that many trees were physically damaged, probably from snowmobile use of the area. Many terminal buds had been destroyed and laterals were taking over.

1991 Trials

Cochrane – The Cochrane trial is in Homuth Township, about 40 km north of Smooth Rock Falls, and 8 km west of Highway 634 (Figure 1). The previous stand was Sb_{10}, 120 years old, 17 m tall, 0.7 stocking and site class 1 (Ecosite 8). The site was full tree mechanically harvested in the winter of 1989 and 1990. Site preparation was with a shearblade in 1991, creating a competition-free site for planting. Overwinter and bareroot stock were planted on May 29, 1991, under sunny and warm (21°C) conditions with one day of rain three days prior to the plant. Current stock were planted on June 18, 1991 under sunny and warm (28°C) conditions, with two days of rain one week prior to the plant.

Competition was not a problem on this site. No tending occurred during the course of the trial. The site suffered late spring frost damage in 1992, with 27 percent of the trees showing damage.

Hearst – The Hearst trial is in Elgie Township, about 10 km southwest of Nagagamisis Provincial Park and about 300 m west of the West Elgie Road (Figure 1). The previous stand was a $Sb_6B_3Ce_1$, 130 years old, 15 m tall, 0.4 stocking, site class 2 (Ecosite 6f). The site was flat and with a clay soil. The area was clearcut with the cut and skid method in 1989. Residuals on the site included poplar, white birch, black spruce and balsam fir. Site preparation was with prescribed burning in 1990.

Initial competition was moderate to heavy from grasses, herbs and shrubs. Chemical tending with glyphosate in 1992 reduced competition for the remainder of the trial.

Heavy frost damage (-5°C) after bud flush occurred on June 19 and 20, 1992 and damaged 89 percent of the trees. The trees recovered within one year.

Kapuskasing – The Kapuskasing trial is in Sulman Township, about 22.4 km southwest of Kapuskasing on Cargill Road, and 700 m past Mile 14 marker (Figure 1). The previous stand was a Sb_9L_1, 95 years old, 16 m tall, 1.0 stocking and site class 1 (Ecosite 12). The site was a well-drained lowland black spruce flat. The site was full tree logged in the winter of 1990–1991 using a tracked feller buncher. No site preparation was done due to the lack of slash. Overwinter and bareroot stock were planted on May 29, 1991 under warm (17°C to 21°C) and sunny conditions. There had been 19.4 mm of rain within two days before the plant and 8 mm the day after the plant. Current stock was planted on June 17 under warm (16°C to 27°C) and dry conditions. There had been 8.4 mm of rain the previous day, but no rain for eight days after the plant.

Initial competition was light, with some shrub and herb regrowth. This increased over the course of the trial, and by 1997 competition was heavy in most replicates from alder, willow, other shrubs, herb, grass and sphagnum growth. The site was affected by late spring frosts in 1992, similar to the other trials.

Timmins – The Timmins trial is located in Macklem Township about 3 km south of Highway 101, and about 1 km south of Legare Lake (Figure 1). The area is flat with clay soils. The previous stand was a $Po_6Sb_2B_1Bw_1$, 44 years old, 15 m tall, 1.0 stocking and site class 3 (Ecosite 6f). The site was clearcut in 1989, with some residual poplar and birch. During the winter of 1989–1990, a D8 with a straight blade was used to site prepare the area into

corridors. Bareroot and overwinter stock were planted on May 22 and 23, 1991 under warm and dry conditions. Current stock was planted on June 18, 1991, also under warm and dry conditions.

Initial competition was from aspen suckering and shrub regrowth in the corridors. Chemical tending with glyphosate in fall 1992, temporarily reduced the competition. The final assessment in 1997 found moderate competition with minor white pine weevil damage.

JACK PINE TRIALS

1987 TRIALS

Three stock type categories were used in trials established in 1987: current, overwinter and bareroot. Chapleau District established two trials: Copperfield Township (3) and Strom Township (2). Two other districts established one trial each: Cairo Township (2) in Kirkland Lake District and Kenogaming Township (3), Timmins District. (Note: the numbers in brackets after each township mentioned in the text indicates the ecosite.)

The four trials had wide variation in height growth. The trials planted on coarse soil mixedwood ecosites in Copperfield and Kenogaming Townships, had the best growth (Figure 2). The error bars on this and subsequent graphs, represent the mean ± one standard error. The two trials planted on jack pine ecosites, Strom and Cairo Townships, had the poorest growth. Bareroot stock consistently had the best height growth on all sites, significantly better ($p < 0.05$) than current and overwinter stock. Current stock usually had the poorest height growth and overwinter stock had intermediate height growth, usually not significantly greater than current stock ($p > 0.05$), except on the Kenogaming Township site where overwinter stock was significantly taller than current stock ($p = 0.03$). After five years, the tallest seedlings were bareroot stock on the Kenogaming site (mean height = 187 cm) and the shortest seedlings were current stock on the Strom Township site (mean height = 74 cm).

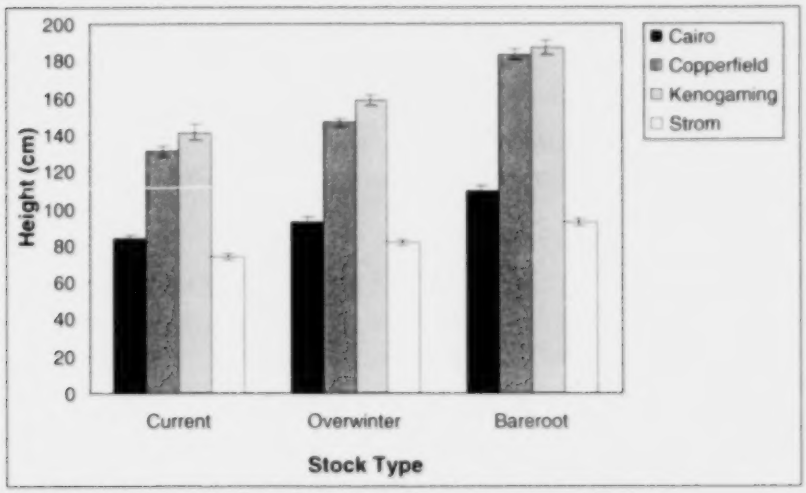

Figure 2. 1987 Jack Pine Fifth-Year Measurements – Height.

The general trend in height growth for these sites was similar for all stock types (Figure 3). We selected only one trial for this data for each year because most of the curves were similar. Two distinct growth stages were observed. Height increments for the first three years were relatively constant, reflecting an initial period of tree establishment. Beyond this period growth rates increased exponentially. The lines shown in this and similar figures are based on yearly means by stock types. They are *not* fitted regression lines.

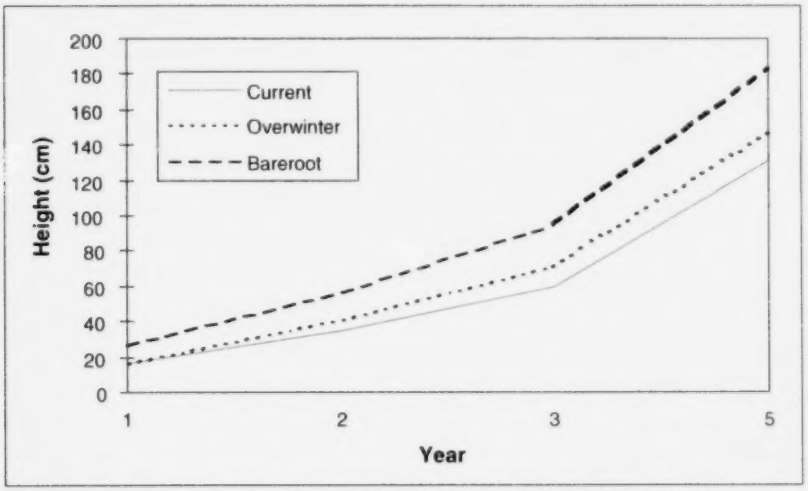

Figure 3. 1987 Jack Pine Annual Height Growth – Copperfield.

Seedling diameters had the same variation as heights (Figure 4). Bareroot stock had significantly greater diameters ($p < 0.05$) than current stock on all four sites. Overwinter stock diameters were intermediate to the other two stock types, but did not differ significantly ($p > 0.05$) on any sites. After five years, the largest diameter was 37 mm for bareroot stock on the Kenogaming Township site, and the smallest diameter was 11.5 mm for current stock on the Cairo Township site.

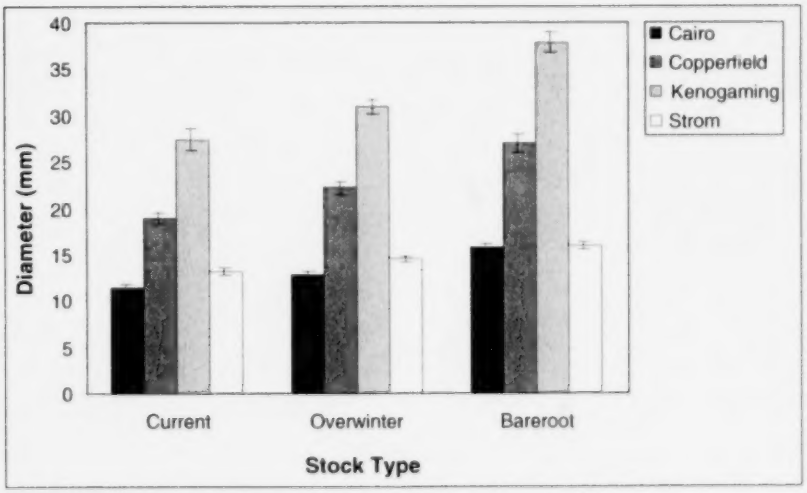

Figure 4. 1987 Jack Pine Fifth-Year Measurements – Diameter.

Bareroot stock had a significantly greater ($p < 0.05$) current annual height increment (CAHI) than current stock on all sites except the Strom Township site (Figure 5). Bareroot stock also had a significantly greater CAHI than overwinter stock on the Kenogaming Township site. Overwinter stock had a significantly greater CAHI than current stock on the Strom ($p = 0.025$) and Kenogaming Townships sites ($p = 0.015$). Overwinter stock did not differ significantly in any other stock type comparisons ($p > 0.05$). The highest annual increment was 50.4 cm/yr for bareroot stock on the Kenogaming Township site, and the poorest increment was 15.7 cm/yr for current stock on the Strom Township site.

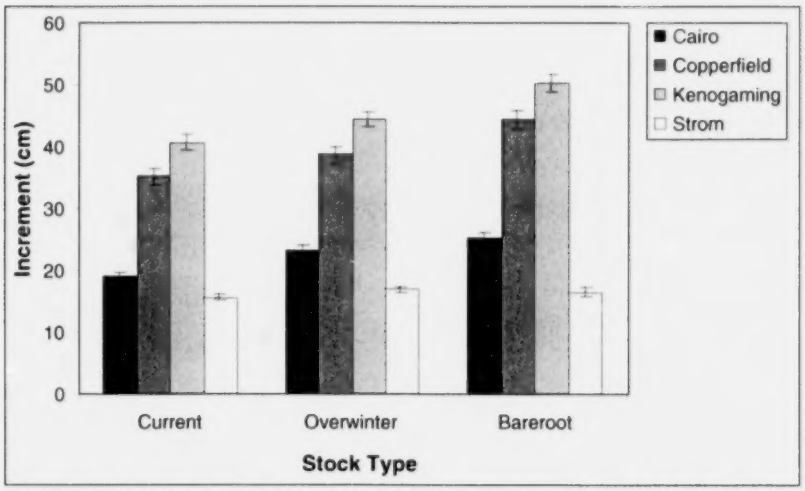

Figure 5. 1987 Jack Pine Fifth-Year Measurements – Current Annual Height Increment.

Survival was at least 80 percent for all stock types on all trials (Figure 6). The exception was with current stock on the Copperfield Township site, with a mean survival rate of 79.7 percent (poorest survival for this year). No obvious trends were evident from the analyses. Current stock had significantly lower survival rates ($p = 0.047$, mean = 79.7 percent) than bareroot stock (mean = 90.4 percent) on the Copperfield Township site. Current stock also had significantly lower survival ($p = 0.03$, mean = 83.3 percent) than overwinter stock (mean = 92.7 percent) on the Strom Township site. Bareroot stock survival was significantly lower ($p < 0.001$, mean = 83.2 percent) than current stock (mean = 93.3 percent) on the Kenogaming Township site. Survival did not differ between stock types at the Cairo Township site ($p > 0.05$). The best survival was 97.6 percent for overwinter stock on the Cairo Township site.

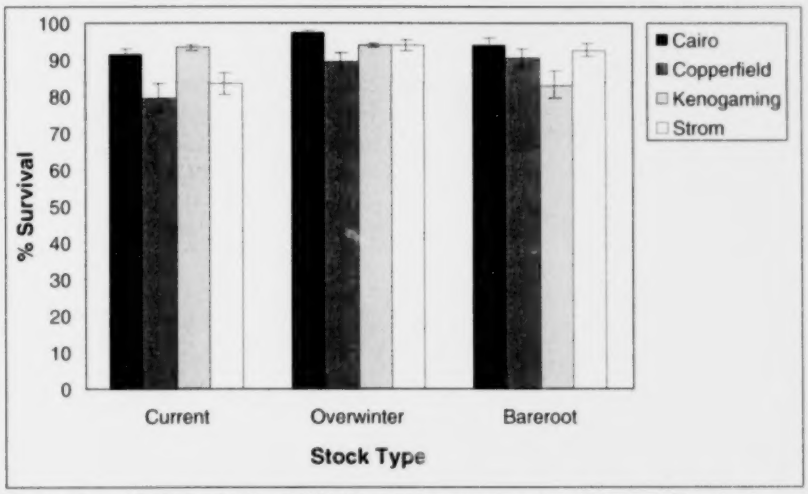

Figure 6. 1987 Jack Pine Fifth-Year Measurements – Percent Survival.

Most mortality occurred by the end of the third growing season after planting (establishment phase). In bareroot stock, 70 to 90 percent of the mortality observed to the end of the fifth growing season occurred by this time on all four sites (Figure 7). The two container stocks were consistent with bareroot stock on all sites except for Kenogaming Township, where only half of the mortality had occurred by the third year. However, since survival at this site was over 93 percent, random mortality of a few trees would influence cumulative mortality rates.

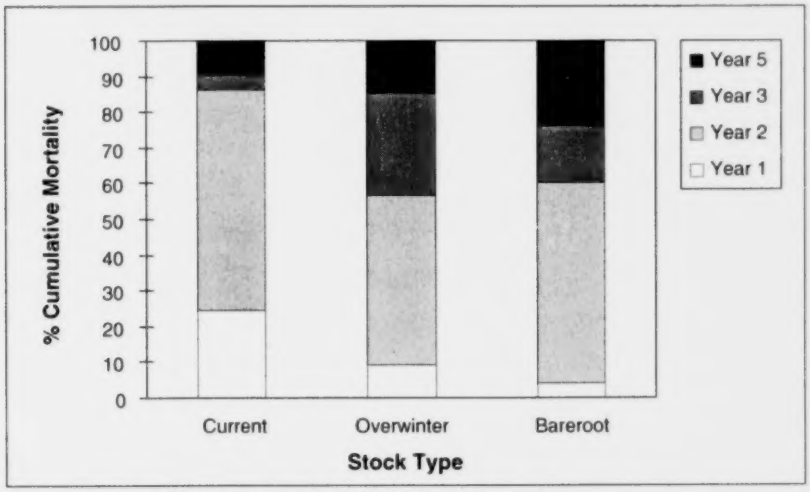

Figure 7. 1987 Jack Pine Cumulative Mortality – Cairo.

Performance index differences between sites and stock types were similar to height and diameter differences (Figure 8). Bareroot stock had significantly better performance index means than current stock ($p < 0.05$) on all sites. Overwinter stock was significantly better ($p = 0.007$) than current stock on the Strom Township site. The best performance index was 166.7 cm for bareroot stock on the Copperfield site, and the poorest performance index was 60.1 cm for current and bareroot stock on the Strom Township site.

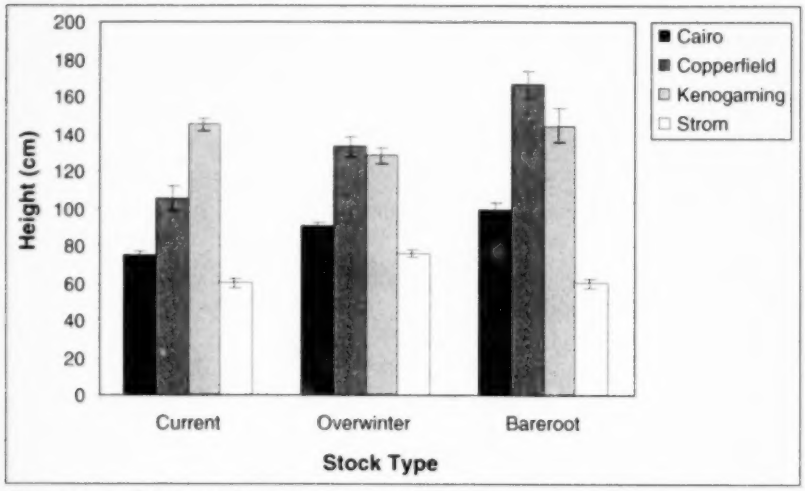

Figure 8. 1987 Jack Pine Fifth-Year Measurements – Performance Index.

Bareroot stock relative growth rates were significantly better than current stock relative growth rates ($p < 0.05$) on all sites (Figure 9). Overwinter stock relative growth rates were significantly better than current stock ($p < 0.05$) on the Copperfield and Kenogaming Township sites. Bareroot stock relative growth rates were also better ($p < 0.05$) than that of overwinter stock on these same sites.

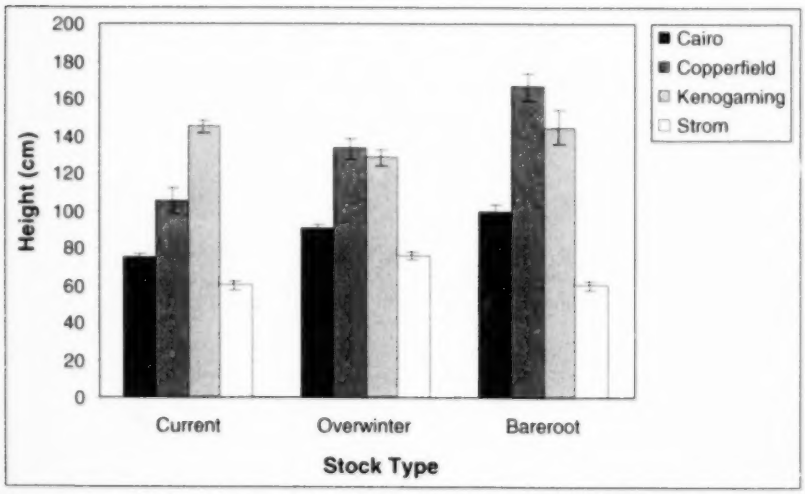

Figure 9. 1987 Jack Pine Fifth-Year Measurements – Relative Growth Rate.

Three stock type categories were used in trials established in 1988: current, overwinter and bareroot. Chapleau District established two trials: Copperfield Township (3) and Hutcheon Township (2). Two other districts established one trial each: Garibaldi Township (2) in Gogama District and Elgie Township (3) in Hearst District.

Overwinter and bareroot stock had significantly better height growth ($p < 0.05$) than current stock on all sites except for the Hutcheon site (Figure 10). On this site, current stock was similar in height to bareroot stock ($p > 0.05$), but overwinter stock was significantly taller than bareroot and current stock ($p < 0.05$). Bareroot stock was significantly better than overwinter stock on the Garibaldi site ($p < 0.001$) but on the other two sites they were similar in height ($p > 0.05$). Heights after five years ranged from a minimum of 81.2 cm for current stock on the Garibaldi site to a maximum of 179.6 cm for bareroot stock on the Elgie site. The Garibaldi site had the poorest height growth for the 1988 trials.

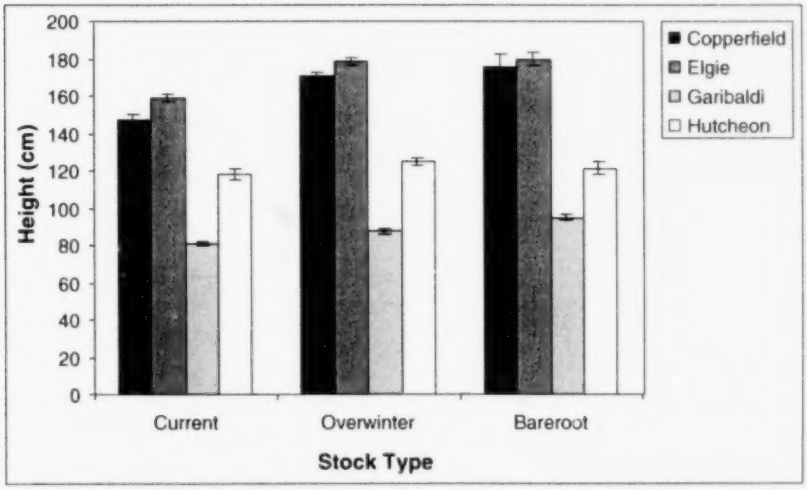

Figure 10. 1988 Jack Pine Fifth-Year Measurements – Height.

Height growth over time for these sites showed the initial establishment phase for the first three years and an exponential increase in the last two years (Figure 11).

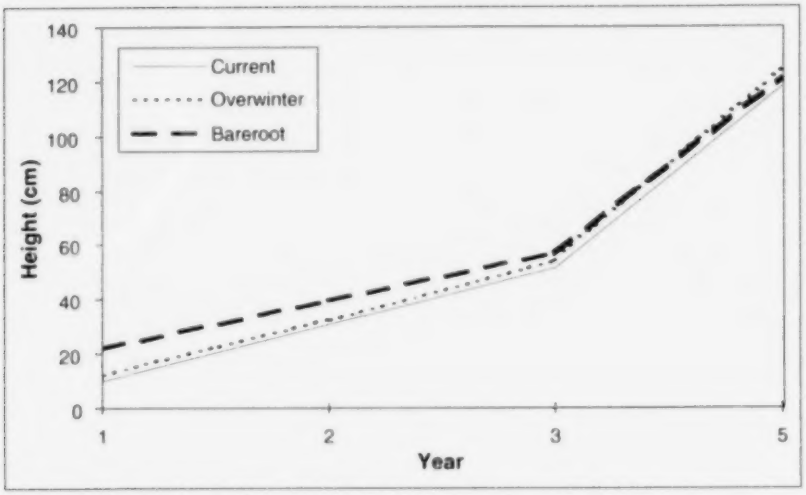

Figure 11. 1988 Jack Pine Annual Height Growth – Hutcheon.

Current stock had the smallest diameters, significantly less ($p < 0.05$) than that of overwinter and bareroot stock (Figure 12). The exception was on the Hutcheon site, which had no differences between bareroot and current stock. Overwinter stock was similar in diameter to bareroot stock on all sites except Garibaldi, where bareroot was larger in diameter than overwinter stock ($p < 0.05$). After five years, diameters ranged from 12.7 mm for current stock on the Garibaldi site to 32.1 mm for bareroot stock on the Copperfield site.

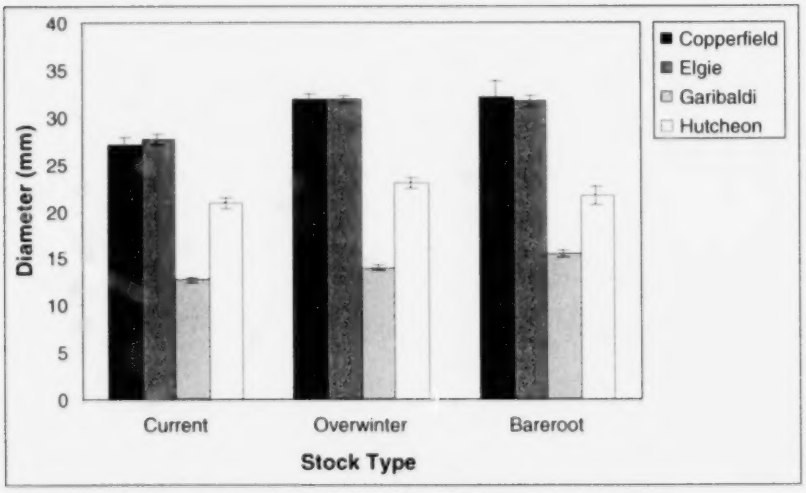

Figure 12. 1988 Jack Pine Fifth-Year Measurements – Diameter.

There were no differences between stock types for CAHI at the Copperfield site (Figure 13). On the other three sites, trends were not consistent. Overwinter stock had a significantly better CAHI than current stock on the other sites ($p < 0.05$). Bareroot stock had a significantly better CAHI than current stock on the Garibaldi and Elgie sites ($p < 0.05$). Overwinter stock also had a significantly better CAHI than bareroot stock on the Hutcheon site but not on any of the other sites. Current annual height increments varied from a minimum of 19.8 cm/yr for current stock on the Garibaldi site to a maximum of 53.6 cm/yr for overwinter stock on the Elgie site.

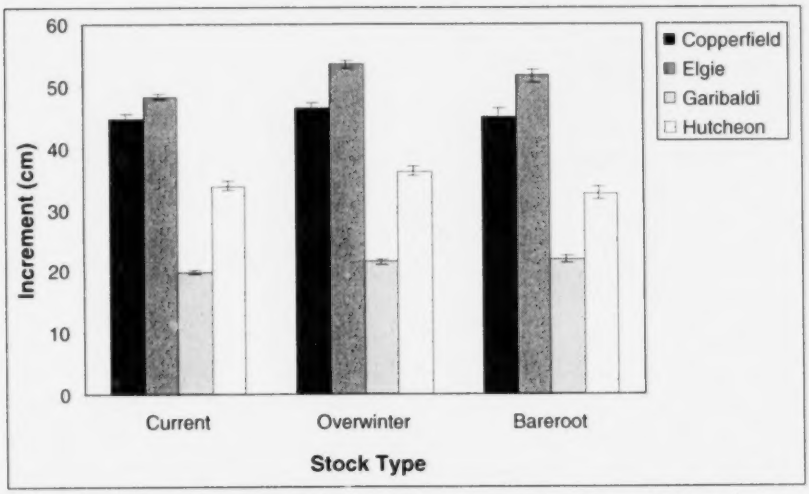

Figure 13. 1988 Jack Pine Fifth-Year Measurements – Current Annual Height Increment.

Survival was high for all sites and stock types (> 85 percent) except for a 65 percent survival rate for bareroot stock on the Copperfield site (Figure 14). Bareroot stock had significantly lower survival rates than the two container stock types on all sites ($p < 0.05$) except for the Hutcheon site. Overwinter stock survival was similar to current stock survival for all sites except for the Copperfield site, where overwinter stock survival was significantly better ($p < 0.05$) than current stock survival. No significant differences in survival were found on the Hutcheon site ($p > 0.05$).

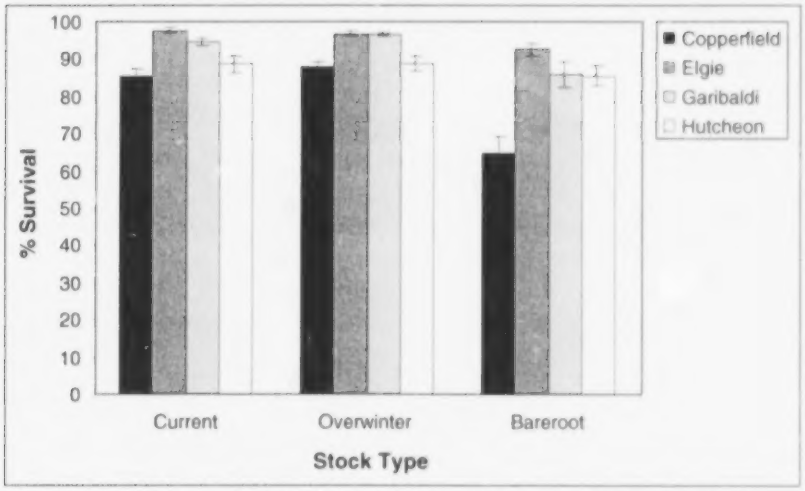

Figure 14. 1988 Jack Pine Fifth-Year Measurements – Percent Survival.

Cumulative mortality rates varied more compared to the 1987 trials (e.g. Copperfield). This could be due to the high survival rates, so the loss of a few trees towards the end of the trial would change the percent cumulative mortality.

Overwinter stock had a significantly higher ($p < 0.05$) performance index than current and bareroot stock on all sites except Hutcheon, where no differences were found (Figure 15, $p > 0.05$). Bareroot stock had a significantly higher ($p < 0.05$) performance index than current stock on the Elgie site, but not on the other sites. The best performance index was with overwinter stock on the Elgie site (mean height = 172.4 cm) and the poorest performance index was for bareroot stock on the Garibaldi site (mean height = 72.5 cm).

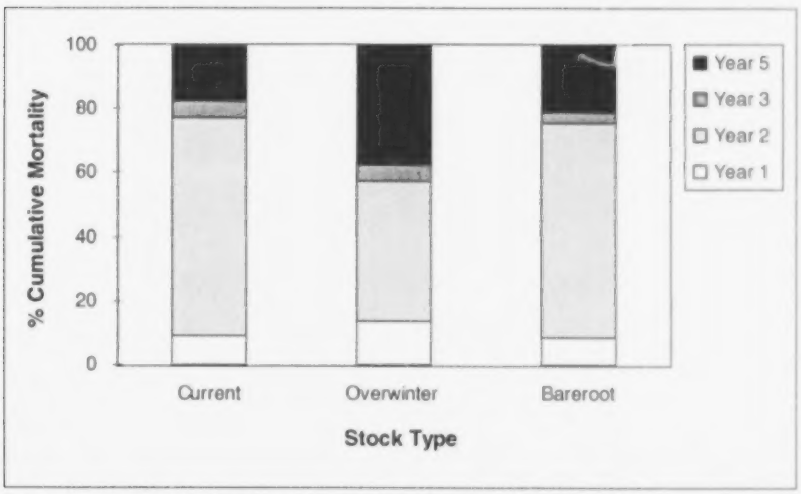

Figure 15. 1988 Jack Pine Cumulative Mortality – Copperfield.

Overwinter stock had significantly better ($p < 0.05$) relative growth rates than current stock on all four sites (Figure 16). Bareroot stock had better relative growth rates ($p < 0.05$) than current stock on all sites except the Hutcheon site, where no differences were found. Bareroot had similar relative growth rates ($p > 0.05$) to overwinter stock on all sites except for the Garibaldi site, where bareroot was significantly better. In general, bareroot and overwinter stock have similar relative growth rates; usually higher than for current stock.

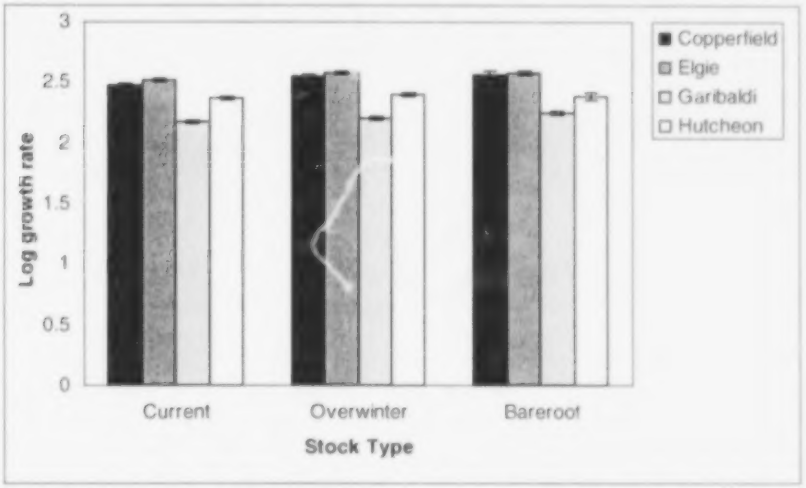

Figure 16. 1988 Jack Pine Fifth-Year Measurements – Relative Growth Rate.

1989 Trials

Trials established in 1989 used only two jack pine stock types, current and overwinter, as bareroot stock had been discontinued. Chapleau District had two sites established: Paul Township (2) and Hutcheon Township (2). The other districts established one trial each: MacMurchy Township (3), Gogama District; Michie Township (2), Kirkland Lake District and Lessard Township (7m), Hearst District.

Overwinter stock were similar to current stock on all sites for height, diameter, performance index, survival and relative growth rate except in three cases.

Overwinter and current stock had similar heights on all sites except for the Paul Township site (Figure 17). On this site overwinter stock was significantly taller than current stock ($p = 0.043$), but the difference in means was only 4.5 cm. There was a much greater range in heights between sites. The least growth was 108.2 cm for current stock on the Paul site, and the best growth was 156.6 cm for overwinter stock on the MacMurchy site.

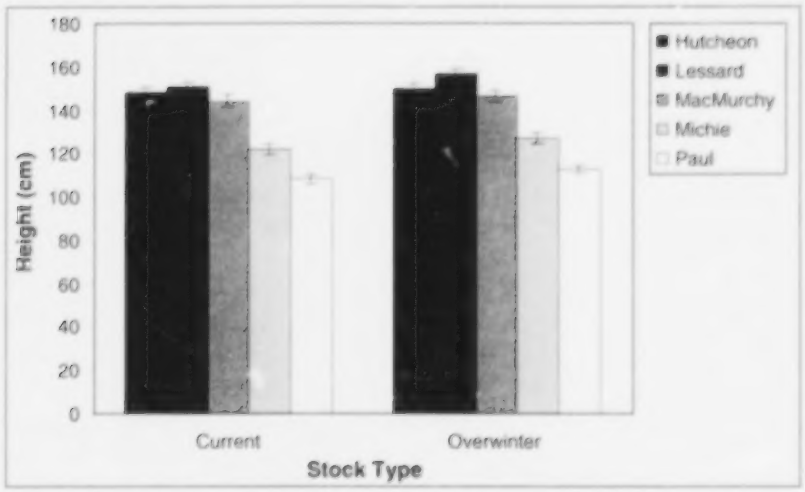

Figure 17. 1989 Jack Pine Fifth-Year Measurements – Height.

Most sites exhibited an initial establishment phase, followed by exponential growth (Figure 18), except for the Paul site. On the Paul site, annual height increments were constant and did not differ greatly between the first three years and the last two.

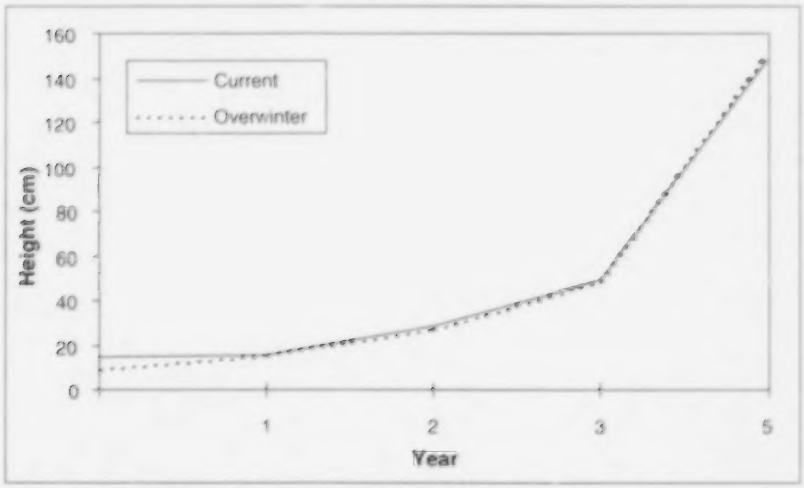

Figure 18. 1989 Jack Pine Annual Height Growth – Hutcheon.

Diameter growth did not vary between current and overwinter stock for any site (Figure 19). The least diameter growth was 20.5 mm for current stock on the Paul site, and the best diameter growth was 28.4 mm for overwinter stock on the MacMurchy site.

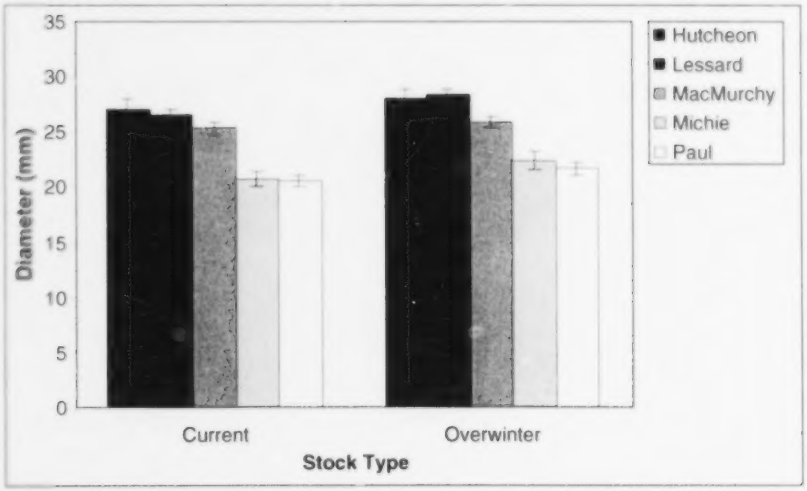

Figure 19. 1989 Jack Pine Fifth-Year Measurements – Diameter.

Current annual height increment did not differ significantly between stock types for any site (Figure 20). The difference between stock types for any site was less than 2.4 cm. The least CAHI was 19.3 cm/yr for current stock on the Paul site, and the best CAHI was 50.4 cm/yr for overwinter stock on the Hutcheon site.

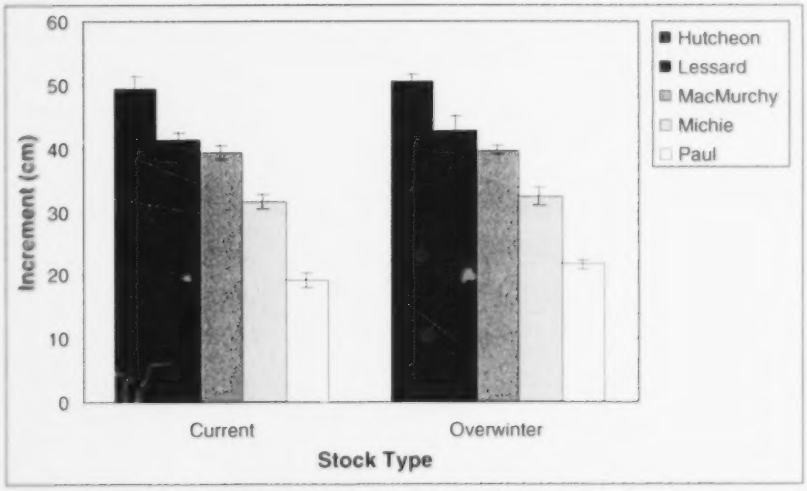

Figure 20. 1989 Jack Pine Fifth-Year Measurements – Current Annual Height Increment.

Survival was excellent for all stock types (Figure 21). The only significant difference was on the Lessard site, where overwinter stock has significantly greater survival than current stock ($p = 0.01$). Mean percent survival ranged from 92 percent for current stock in the MacMurchy site to 97 percent on the Lessard site.

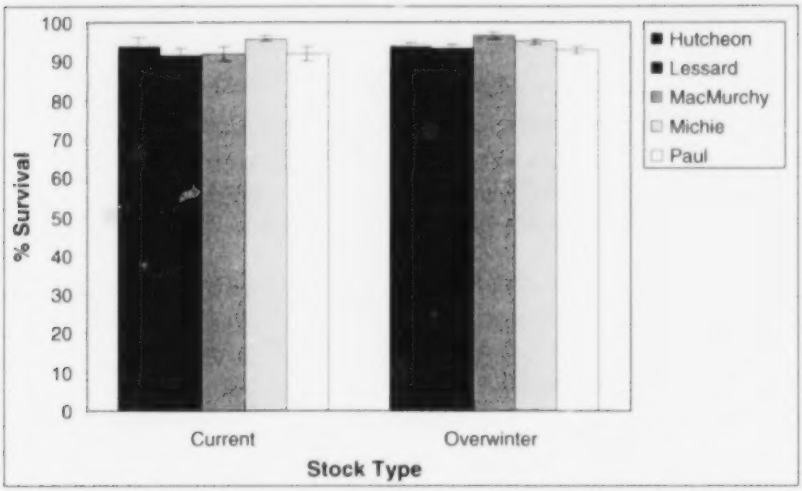

Figure 21. 1989 Jack Pine Fifth-Year Measurements – Percent Survival.

On the Lessard (Figure 22) and Michie sites, just over 70 percent of the mortality had taken place by the third growing season. On the other sites most of the mortality took place after the first three years (40 percent and more).

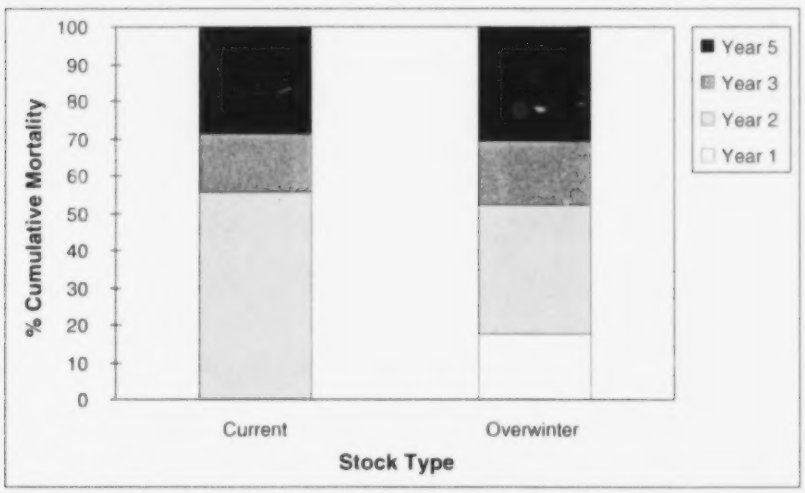

Figure 22. 1989 Jack Pine Cumulative Mortality – Lessard.

Performance index did not differ between stock types for any site ($p > 0.05$, Figure 23). The best performance index was 145.5 cm for overwinter stock on the MacMurchy site and the poorest performance index was 99.5 cm for current stock on the Paul site.

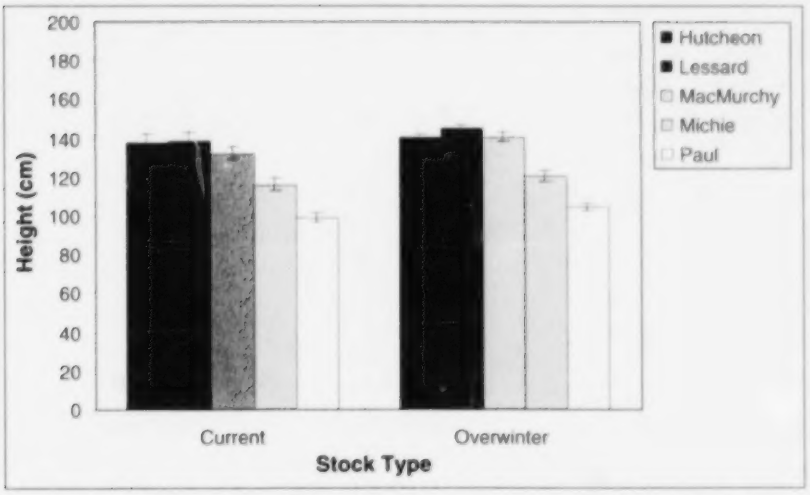

Figure 23. 1989 Jack Pine Fifth-Year Measurements – Performance Index.

Relative growth rate of overwinter stock was significantly greater than the relative growth rate of current stock on the Paul site ($p = 0.049$, Figure 24). No other differences were noted between stock types at the other sites.

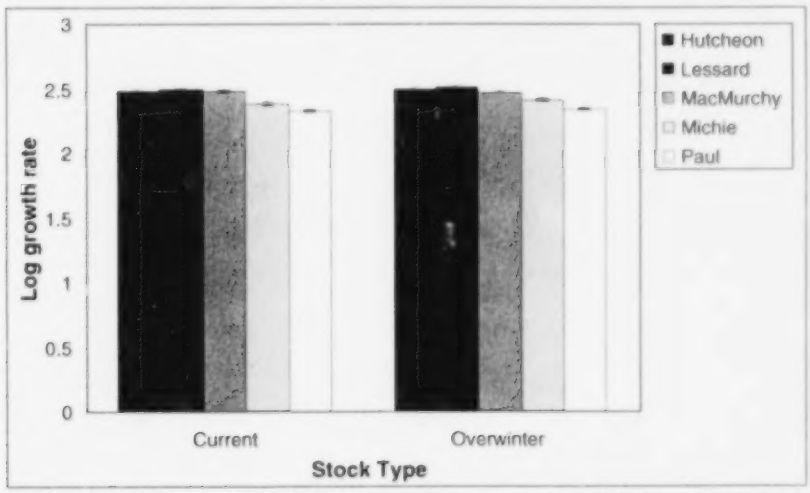

Figure 24. 1989 Jack Pine Fifth-Year Measurements – Relative Growth Rate.

A notable feature in the trials was the poor performance of one of the overwinter stocks for height, diameter, CAHI, performance and relative growth rate on three out of the five sites established this year (Paul, Hutcheon, and Michie). It is not known why this occurred. This may have increased the variance in the means for overwinter stock, hence the absence of significant differences in seedling growth for the variables tested.

The trials this year used current and container stock, the same as in previous years, but also compared jiffypots with paperpots (paperpots had been the only container type used for jack pine in previous years). Stock type and container type were analysed as separate factors. Each district established only one trial: Lincoln Township (2), Chapleau District; MacMurchy Township (3), Gogama District; Elgie Township (3), Hearst District and Burt Township (2), Kirkland Lake District.

Overwinter stock had significantly better height growth than current stock on three out of four sites ($p < 0.05$, Figure 25). The greatest difference was on the Elgie site, with overwinter seedlings having a mean height of 185.4 cm, 26.7 cm greater than the current stock. The Lincoln and MacMurchy sites had height differences of over 23 cm between the two stock types. The Burt site had the poorest growth of all sites (117.7 cm overwinter, 122.3 cm current), with no significant difference between the two stock types ($p > 0.05$). Paperpot stock was significantly better than jiffypot stock for height growth on the Elgie and Burt sites, but not on the other two.

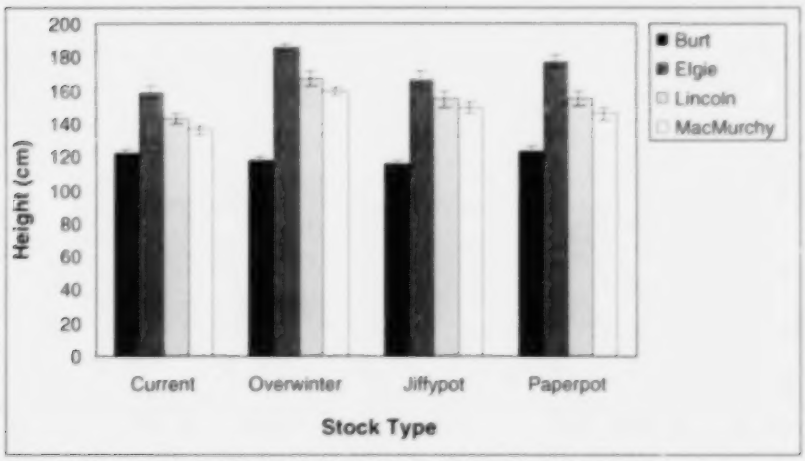

Figure 25. 1990 Jack Pine Fifth-Year Measurements – Height.

All sites exhibited the initial establishment phase, followed by an exponential phase (e.g. MacMurchy, Figure 26).

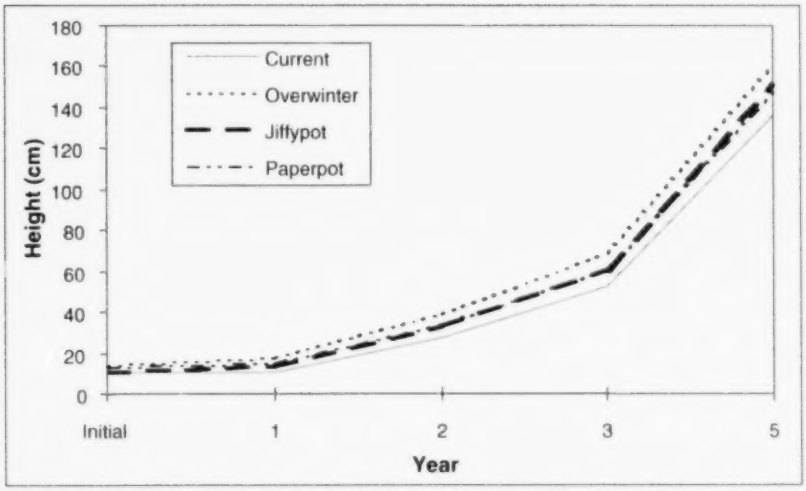

Figure 26. 1990 Jack Pine Annual Height Growth – MacMurchy.

Diameter growth was significantly better for overwinter stock compared to current stock on the same three sites ($p < 0.05$, Figure 27). Burt had no significant differences ($p > 0.05$) between current and overwinter stock types. The largest diameters were with overwinter stock on the Elgie site (33.1 mm), while the smallest diameter seedlings were overwinter stock from the Burt site (20 mm). Paperpot stock was significantly better than jiffypot stock for diameter growth on the Elgie and Burt sites ($p < 0.05$), but did not differ on the other two sites.

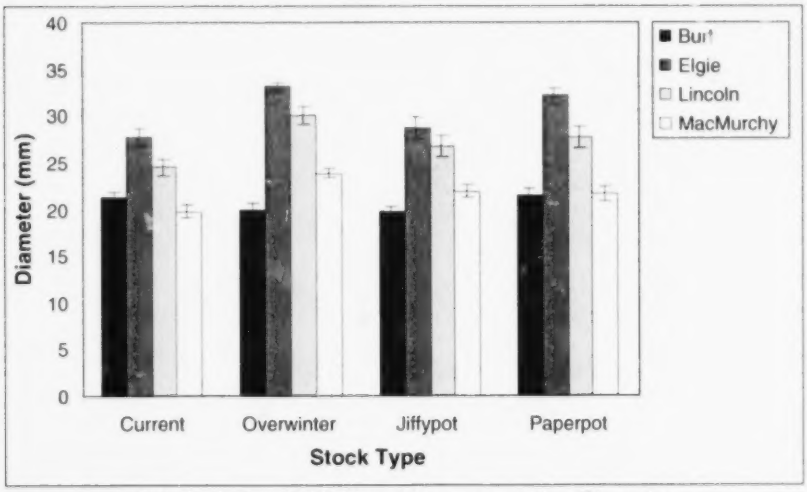

Figure 27. 1990 Jack Pine Fifth-Year Measurements – Diameter.

Current annual height increment was significantly better for overwinter stock compared to current stock on the same three sites as for height and diameter growth ($p < 0.05$, Figure 28). The least CAHI was 36.4 cm/yr for overwinter stock on the Burt site, and the best was 51.6 cm/yr for overwinter stock on the Elgie site. Jiffypots had significantly greater CAHI than paperpots for the MacMurchy site ($p = 0.013$). Container type did not affect CAHI on any other site.

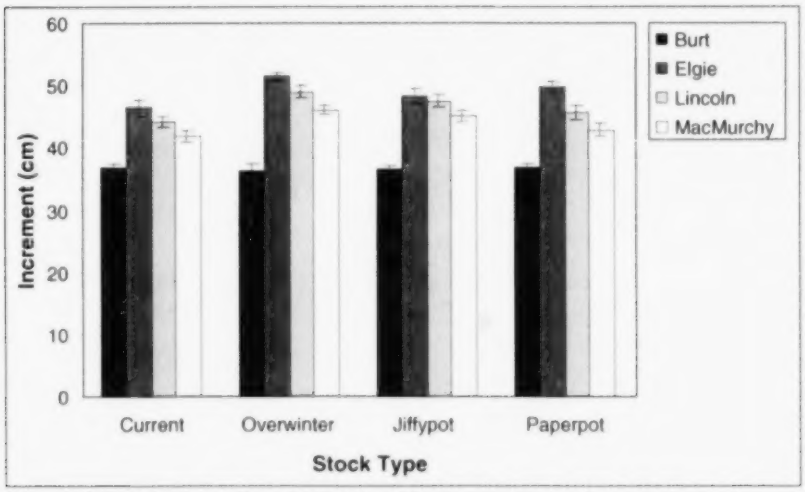

Figure 28. 1990 Jack Pine Fifth-Year Measurements – Current Annual Height Increment.

Survival on all sites was excellent for all stock types (Figure 29). The poorest survival was 77 percent for overwinter stock on the Burt site and the highest was 97 percent for current stock on the MacMurchy site. Except for the poor performance of the overwinter stock on the Burt site, the other stock types reached the minimum survival rate of 90 percent for jack pine. At least 70 percent of the mortality had occurred on most of the sites by the third season (e.g. Elgie, Figure 30).

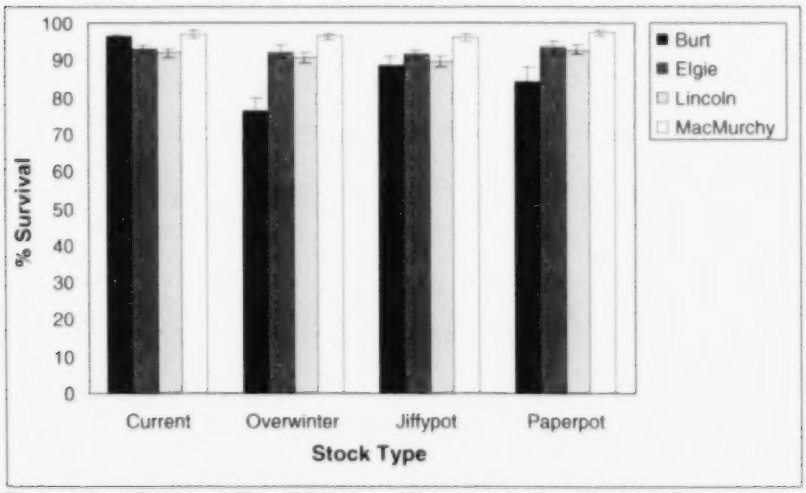

Figure 29. 1990 Jack Pine Fifth-Year Measurements – Percent Survival.

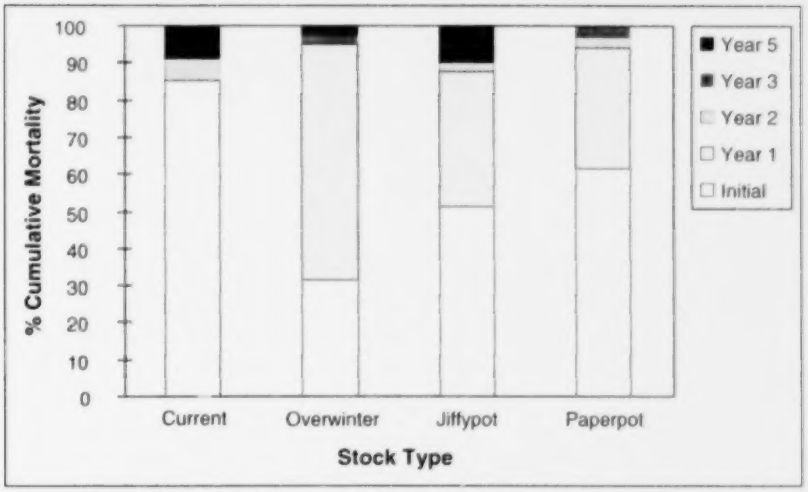

Figure 30. 1990 Jack Pine Cumulative Mortality – Elgie.

Overwinter stock had a higher performance index than current stock on all sites except for the Burt site ($p < 0.05$, Figure 31). On this site, current stock had a higher performance index than overwinter stock ($p < 0.001$) due to the higher mortality of the overwinter stock. Pot type did not affect performance index except on the Elgie site, with paperpots having a significantly higher performance index than jiffypots ($p = 0.01$). The highest performance index was 170.9 cm for overwinter stock on the Elgie site, and the lowest performance index was 88.1 cm for overwinter stock on the Burt site.

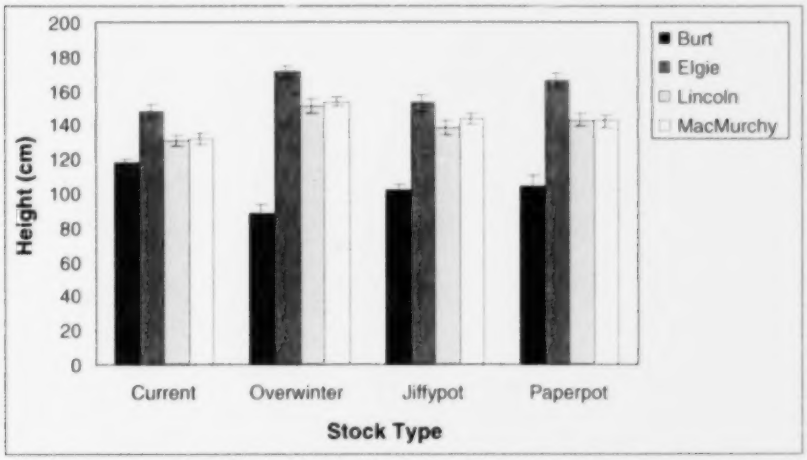

Figure 31. 1990 Jack Pine Fifth-Year Measurements – Performance Index.

Relative growth rates were significantly better ($p < 0.05$) for overwinter stock compared to current stock for all sites except for Burt, where relative growth rates were similar (Figure 32). Paperpots had significantly better relative growth rates ($p < 0.05$) on the Burt and Elgie sites. No differences were found on the other two sites.

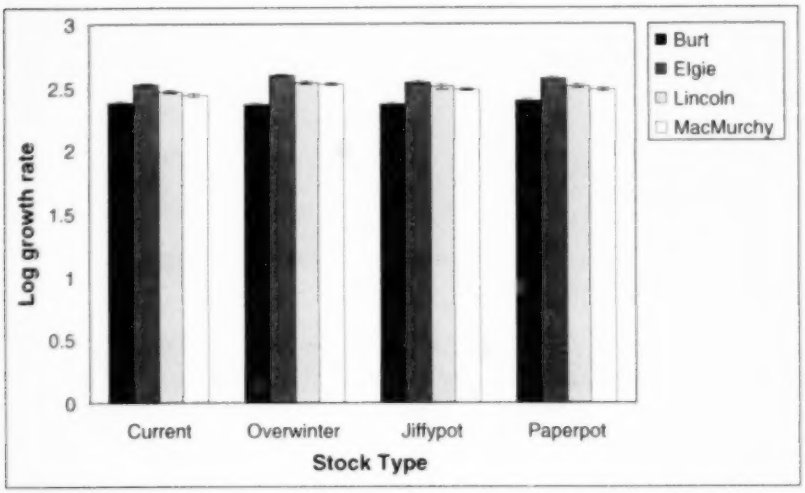

Figure 32. 1990 Jack Pine Fifth-Year Measurements – Relative Growth Rate.

In summary, overwinter stock is superior to current stock for height and diameter growth, current annual height increment, overall performance and relative growth rate. Container type, either 408 paperpot or jiffypot, does not appear to consistently influence any growth parameter. Seedling survival does not appear to be influenced by stock or container type. It is not known why the Burt site had the poorest growth of all sites.

1991 Trials

This year's trials were similar to the 1990 trials. Three districts established trials: Crepieul Township (4), Chapleau District; Elgie Township (6m), Hearst District and Pontiac Township (6m), Kirkland Lake District.

Overwinter stock were significantly taller than current stock on all sites ($p < 0.05$, Figure 33). The shortest seedlings were current stock on the Elgie site (mean height = 94.2 cm) and the best growth was with overwinter seedlings on the Pontiac site (191.6 cm). The greatest difference was on the Crepieul site with the mean height of overwinter stock (166.9 cm) 30.3 cm greater than current stock (133.6 cm). Herbicide spray caused heavy mortality on the Elgie trial in 1991 and severely stunted the surviving seedlings. As a result, mean heights were the least of the three sites (mean height overwinter stock = 132.1 cm; mean height current stock = 94.2 cm). No differences were noted between pot types except on the Elgie site. On this site paperpots had significantly better height growth than jiffypots ($p = 0.007$), but this would be suspect due to the spray damage.

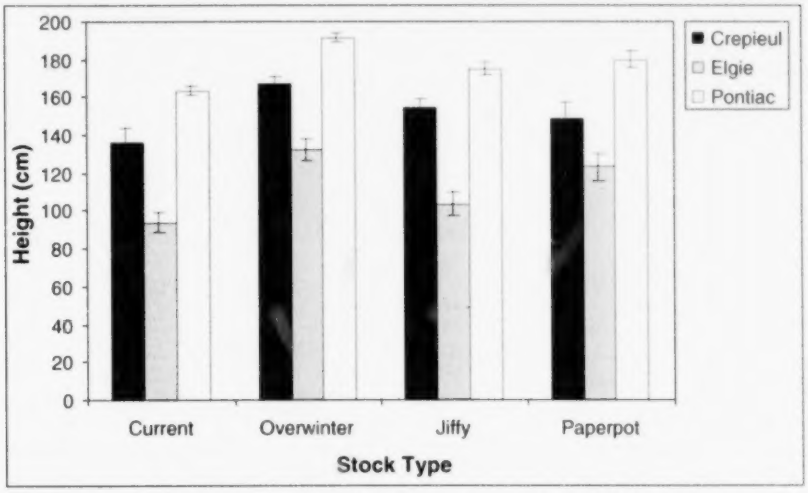

Figure 33. 1991 Jack Pine Fifth-Year Measurements – Height.

These sites were similar to the other years with an initial establishment phase followed by an exponential growth phase (Figure 34).

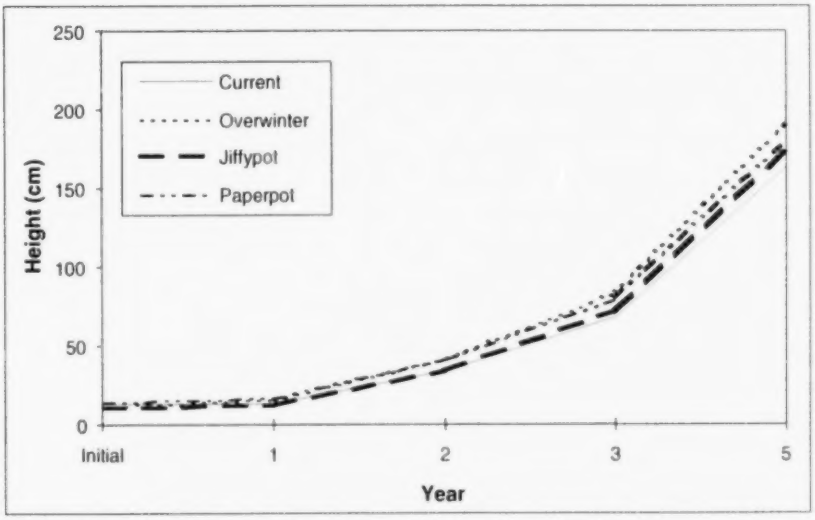

Figure 34. 1991 Jack Pine Annual Height Growth – Pontiac.

Diameter growth was significantly better ($p < 0.05$) for overwinter stock compared to current stock at all sites (Figure 35). The least diameter growth was 21.4 mm for current stock at the Elgie site, and the best diameter growth was 30.4 mm for overwinter stock at the same site. Pot type did not influence growth except at the Elgie site, where paperpots were better than jiffypots ($p = 0.007$).

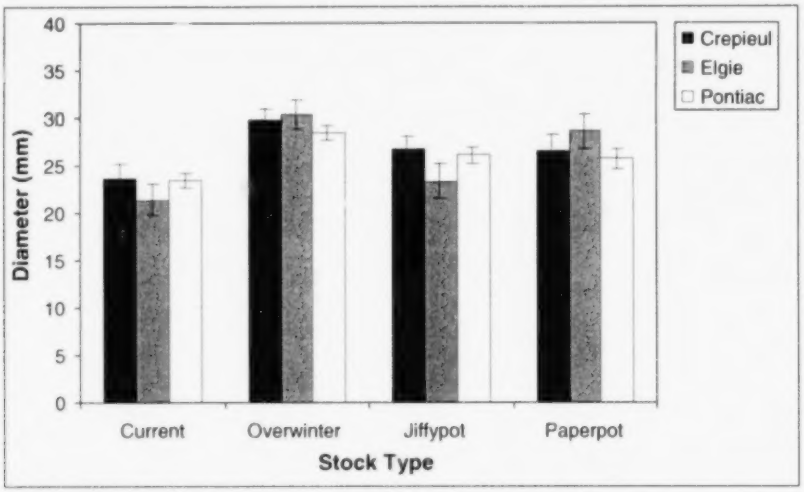

Figure 35. 1991 Jack Pine Fifth-Year Measurements – Diameter.

Current annual height increment was significantly higher for overwinter stock than current stock ($p < 0.05$) on all sites (Figure 36). Ignoring the sprayed Elgie site, the poorest CAHI was 43.2 cm/yr for current stock at the Crepieul site and the best CAHI was 54.5 cm/yr at Pontiac. Pot type did not influence CAHI for any site.

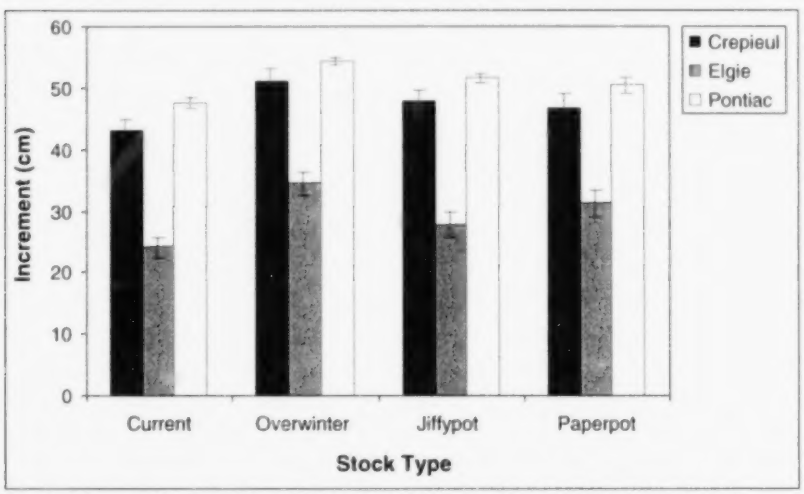

Figure 36. 1991 Jack Pine Fifth-Year Measurements – Current Annual Height Increment.

Survival was excellent on the unsprayed trials and was not influenced by stock or container type (Figure 37). The lowest survival was 83 percent on the Crepieul site and the highest was 98 percent on the Pontiac site. The Crepieul site did not reach the minimum standards for jack pine survival, but Pontiac did. On the sprayed plot (Elgie), survival was 29 percent for current stock and 61 percent for the overwinter stock.

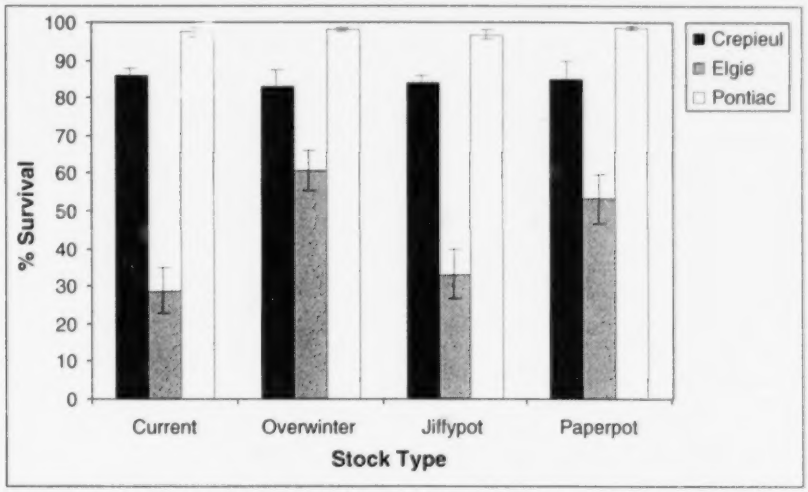

Figure 37. 1991 Jack Pine Fifth-Year Measurements – Percent Survival.

Cumulative mortality rates were variable. On the Crepieul site, about 50 to 60 percent of the mortality observed to year five had occurred by year three. On the Pontiac site, about 75 percent of the current stock mortality had occurred by year three, and most of the overwinter stock (about 70 percent) died between years three and five. However, this site only had two percent mortality (Figure 38).

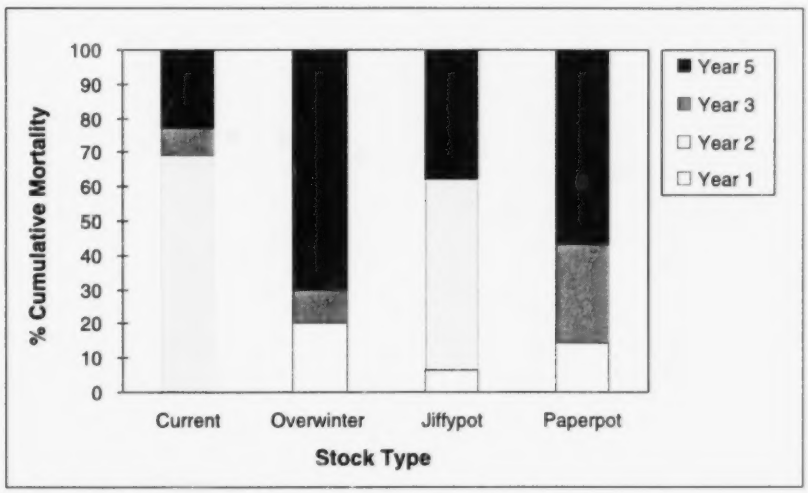

Figure 38. 1991 Jack Pine Cumulative Mortality – Pontiac.

Performance index was significantly higher for overwinter stock ($p < 0.05$) than current stock at the Pontiac and Crepieul sites (Figure 39). The best performance index was 188 cm for overwinter stock at Pontiac and the least was 126 cm for current stock at Crepieul. Pot type did not influence performance index at any site except the sprayed site, where paperpots were significantly better than jiffypots (but this is suspect due to the spraying).

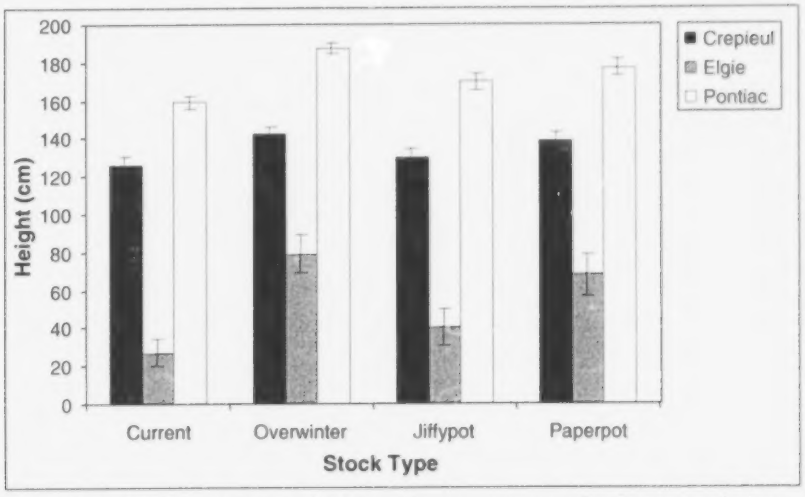

Figure 39. 1991 Jack Pine Fifth-Year Measurements – Performance Index.

Relative growth rate was significantly better for overwinter stock ($p < 0.05$) at all three sites (Figure 40). Pot type did not influence relative growth rate at any site except the Elgie site, where paperpots were significantly better than jiffypots (but this is suspect due to the spraying).

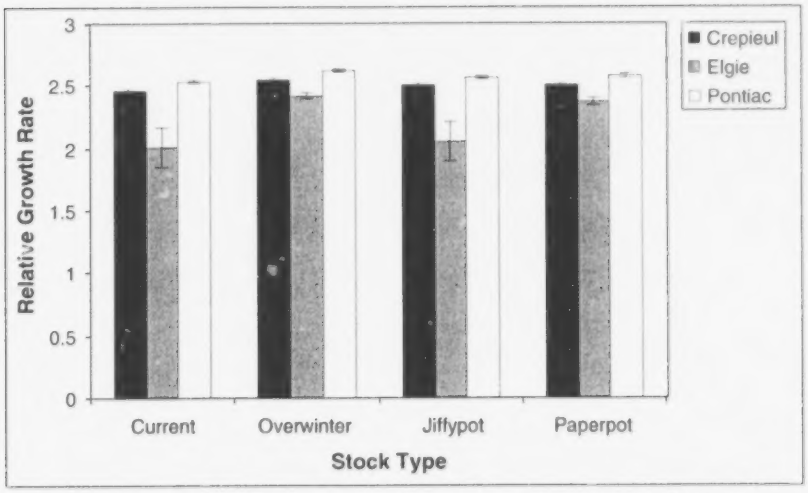

Figure 40. 1991 Jack Pine Fifth-Year Measurements – Relative Growth Rate.

The general trend for the 1991 series was that overwinter stock outdid current stock for height growth, current annual height increment, diameter growth, performance index and relative growth rate. Survival was not influenced by stock type at any site. Container type did not affect any variable.

Black Spruce Trials

1987 Trials

Three black spruce trials were established in 1987: Leitch Township (7f), Cochrane District; Stoddart Township (6f), Hearst District and Cleaver Township (6f), Timmins District.

No significant differences were found between stock types for height growth (Figure 41). Only the current stock (mean height = 93 cm) and overwinter-short day (mean height = 99 cm) stock on the Cleaver site did not reach the free-to-grow minimum height of one metre after seven years. The best growth was for overwinter-short day stock (mean height = 137 cm) on the Leitch site. This site had the best growth of the three sites.

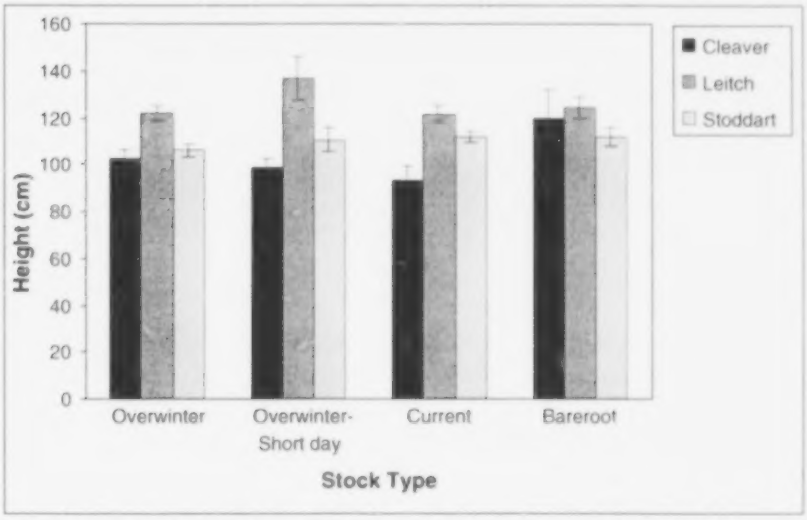

Figure 41. 1987 Black Spruce Seventh-Year Measurements – Height.

Height growth on these sites exhibited an initial establishment phase, similar to jack pine, followed by exponential growth after year three, either as a single increase, or as a stepped increase (e.g. Stoddart, Figure 42).

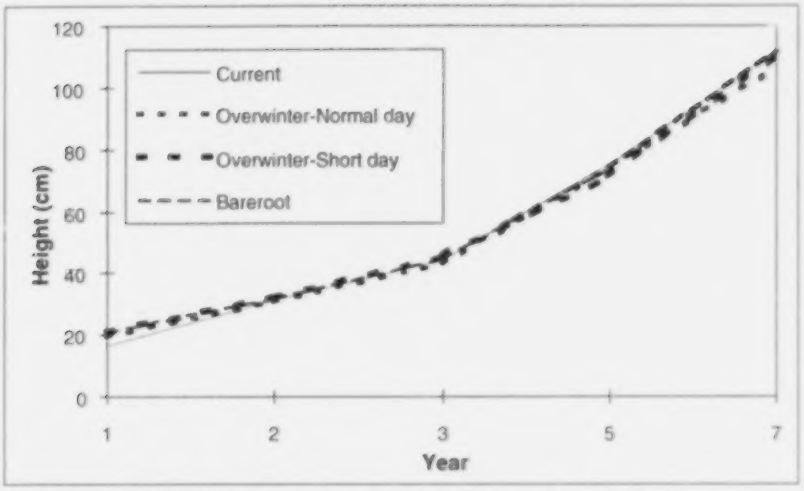

Figure 42. 1987 Black Spruce Annual Height Growth – Stoddart.

Diameter growth did not differ between stock types on any site ($p > 0.05$, Figure 43). The poorest diameter growth was for overwinter-short day stock on the Cleaver site (mean = 12 mm), the same as for heights, and the best diameter growth was for overwinter-short day stock on the Leitch site (mean = 23 mm).

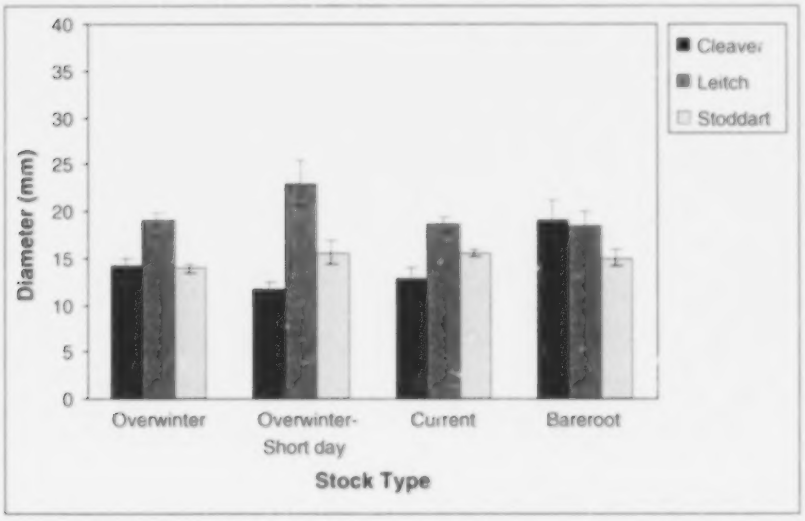

Figure 43. 1987 Black Spruce Seventh-Year Measurements – Diameter.

Current annual height increment (CAHI) did not differ between stock types on any site ($p > 0.05$, Figure 44). The poorest CAHI was 14 cm/yr for both current stock and overwinter-short day stock on the Cleaver site. The best CAHI was 25 cm/yr for bareroot stock on the Leitch site.

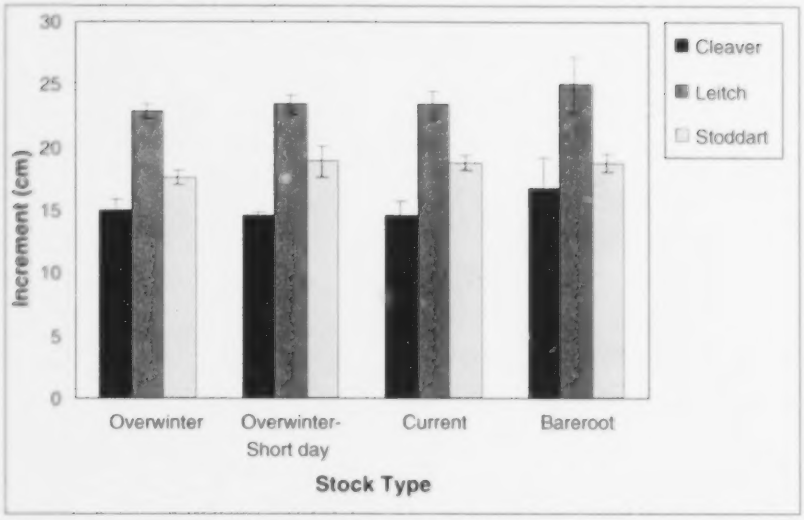

Figure 44. 1987 Black Spruce Seventh-Year Measurements – Current Annual Height Increment.

Survival was not as high for black spruce as it was for the jack pine trials (Figure 45). Significant differences were found only on the Stoddart site, with current stock having better survival than overwinter stock ($p = 0.004$). The poorest survival was 27 percent for bareroot stock on the Cleaver site, and the best was 87 percent for current stock on the Stoddart site. The only stock that reached the minimum standard of 85 percent survival after seven years was current stock on the Leitch and Stoddart sites. The other stock types did not reach this minimum on any site. At least 80 percent or more of the cumulative mortality to year seven observed on these sites had occurred by year five (e.g. Stoddart, Figure 46).

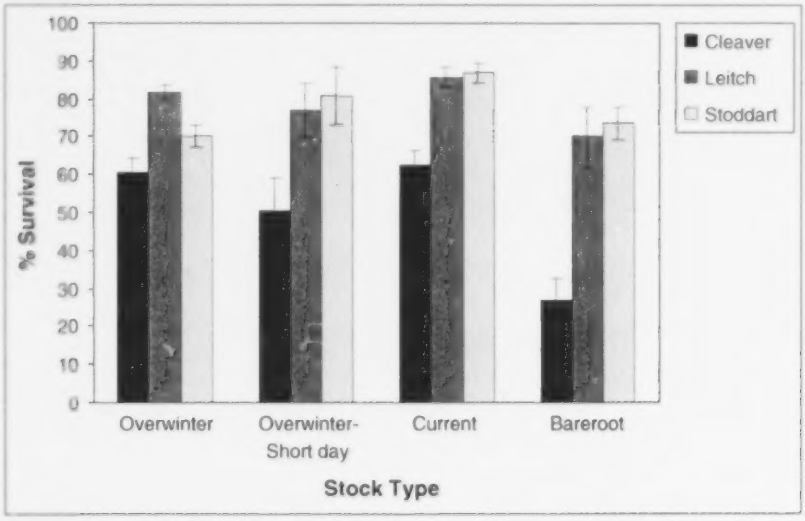

Figure 45. 1987 Black Spruce Seventh-Year Measurements – Percent Survival.

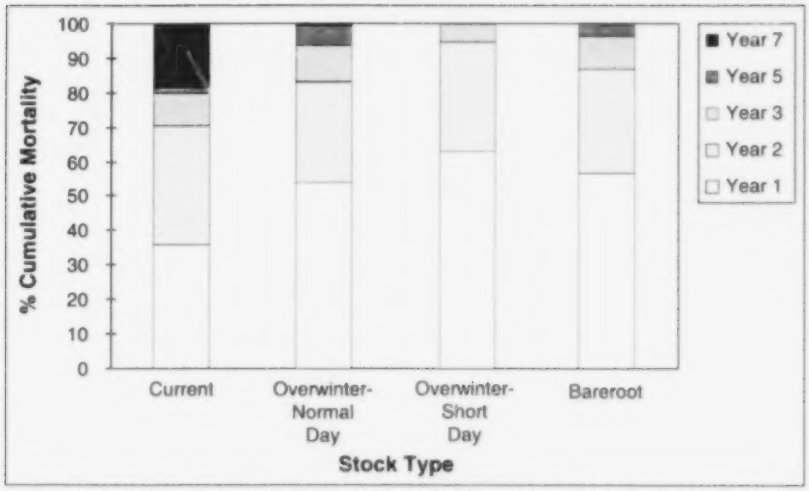

Figure 46. 1987 Black Spruce Cumulative Mortality – Stoddart.

Performance index, like height and diameter, did not differ significantly for most of the sites and stock types ($p > 0.05$, Figure 47). The only significant difference was with current stock having a higher performance index than overwinter stock ($p < 0.001$) on the Stoddart site. The poorest performance index was 31 cm for bareroot stock on the Cleaver site, due to high mortality.

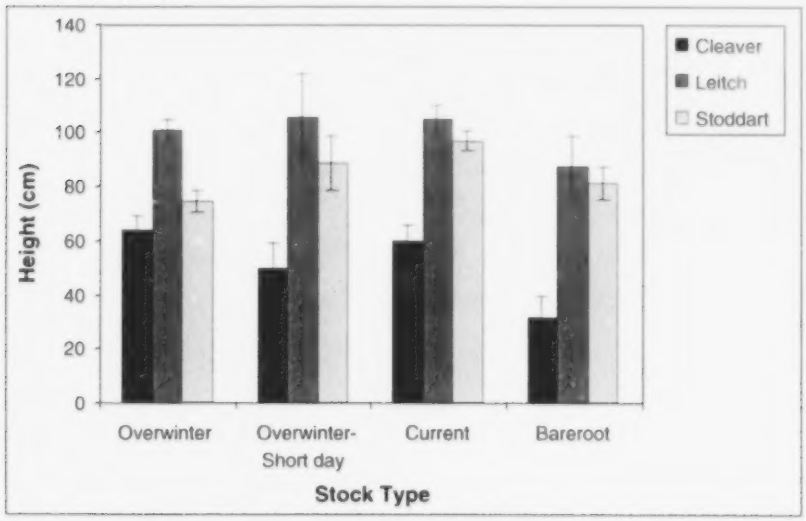

Figure 47. 1987 Black Spruce Seventh-Year Measurements – Performance Index.

Relative growth rates did not differ significantly between stock types on any site ($p > 0.05$, Figure 48).

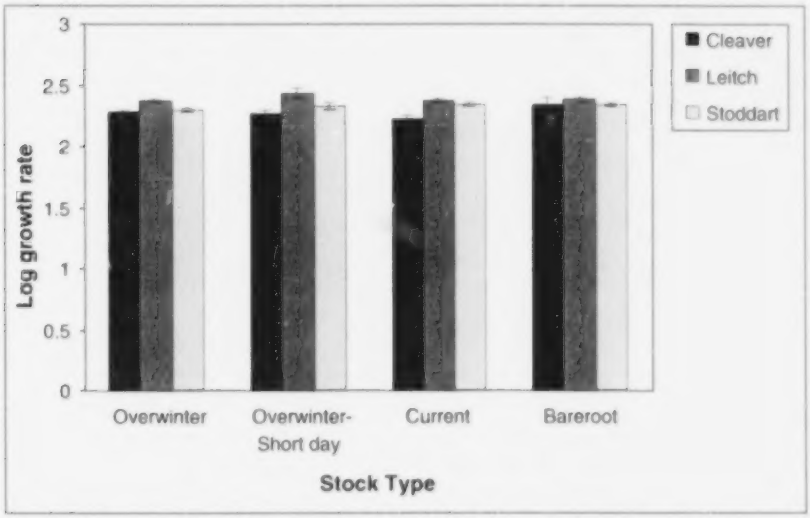

Figure 48. 1987 Black Spruce Seventh-Year Measurements – Relative Growth Rate.

The lack of significant differences between stock types by year seven may be due to wide variation in growth and survival between individual stocks within each stock type. This may have easily obscured any actual differences between stock types. Significant differences were found between stock types during the first few years of the study. The only significant differences in the final survey were noted at the Stoddart site, with current stock outperforming overwinter stock for diameter growth, survival and performance index. Given the lack of significant differences between stock types at the other two sites, these differences should be interpreted with caution.

1988 Trials

The 1988 trials were established on five sites in four Districts: Homuth Township (8), Cochrane District; Arnott (3) and Wicksteed Townships (6c), Hearst District; Gurney Township (12), Kapuskasing District and McArthur Township (2), Timmins District.

Height differences were more consistent in the 1988 trials compared to the 1987 trials (Figure 49). Minimum free-to-grow standards were reached for most stock types on all sites except for Gurney, where no stock type reached the minimum height of one metre. Current stock reached the minimum height on the McArthur site only, and not on any other site. Day length for overwinter stock did not significantly influence height growth ($p > 0.05$). Bareroot and overwinter stock had significantly better height growth than current stock ($p < 0.05$) on all sites. The differences between current and overwinter stock ranged from 10 to 25 cm and 19 to 45 cm for current and bareroot stock. Bareroot stock had better height growth than overwinter stock ($p < 0.05$) on all sites except McArthur, with a difference of 14 to 22 cm. Two-year multipot stock had significantly better growth than medium bareroot ($p < 0.05$) on the Homuth and McArthur site, but did not differ on the other sites. Multipot stock was

generally similar in height to all bareroot stock on most sites except for two. On the McArthur and Homuth sites, multipot stock were significantly better than bareroot stock ($p < 0.008$), with a difference of 25 to 33 cm. The best growth was with multipot stock (mean height = 156 cm) on the McArthur site and the poorest height growth was for current stock (mean height = 68 cm) on the Gurney site.

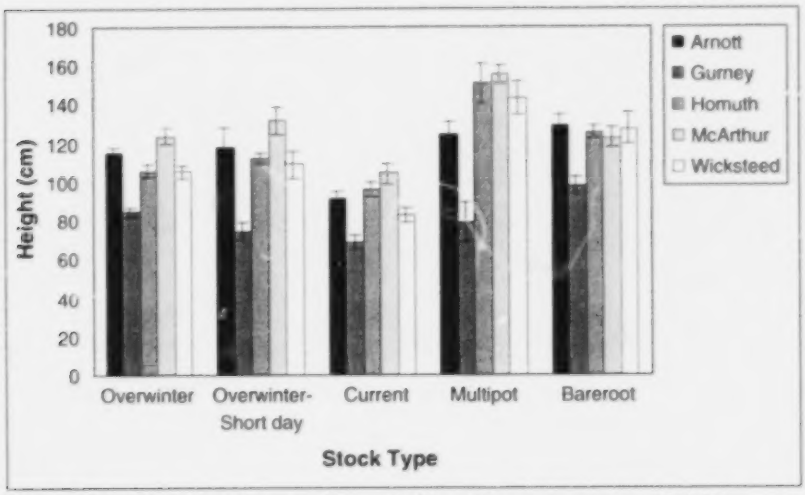

Figure 49. 1988 Black Spruce Seventh-Year Measurements – Height.

Height growth followed the same general trends as for the 1987 trials (e.g. Wicksteed, Figure 50). The first three years are the establishment phase, with a constant growth rate. Growth between year three and seven increased compared to the establishment phase, and in most cases increased between year five and year seven compared to year three to five. The Gurney site had some unusual trends, probably due to site conditions. The growth rate of multipot stock decreased after year five. We could not determine the cause of this growth slowdown.

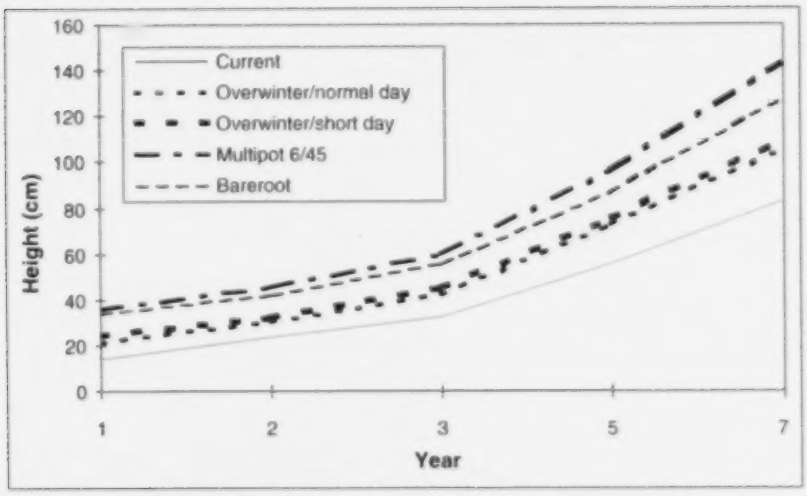

Figure 50. 1988 Black Spruce Annual Height Growth – Wicksteed.

Diameters also showed more variation between stock types compared to the 1987 trials (Figure 51). Significant diameter differences between stock types were similar to height differences, except for three cases. No significant differences were found between current and bareroot stock on the McArthur site, while on the Arnott site, multipot seedling diameters were significantly greater than medium bareroot ($p < 0.001$) and all bareroot ($p = 0.004$). The smallest diameters were 8 mm for current stock on the Gurney site and the largest diameters were 26 mm for multipot stock on the McArthur site.

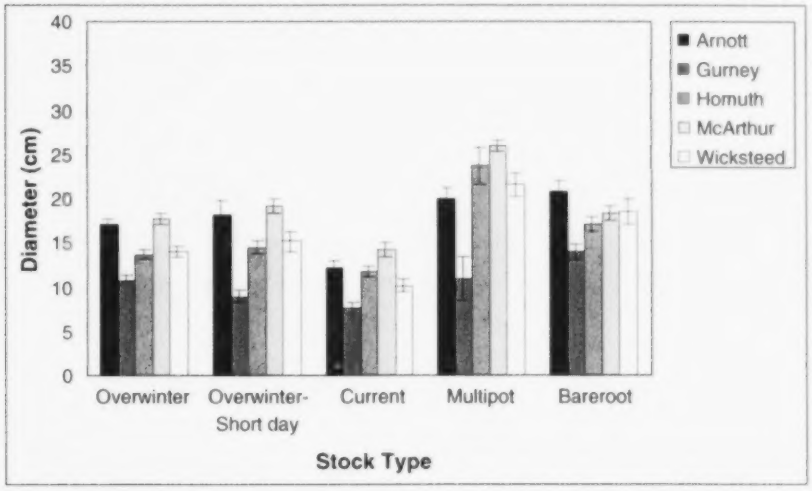

Figure 51. 1988 Black Spruce Seventh-Year Measurements – Diameter.

Current annual height increment had fewer significant differences than height and diameter between stock types (Figure 52). Bareroot stock was significantly greater for CAHI than current stock ($p < 0.05$) for all sites except the McArthur site (no difference). The differences ranged from 4 to 7 cm. The CAHI of overwinter stock was better than for current stock ($p < 0.05$) for the Wicksteed, Gurney and McArthur sites, but the difference was not large (2.5 to 3 cm). Overwinter to normal day stock had significantly better CAHI ($p = 0.03$) than short day stock by 3 cm on the Gurney site. This was the only instance in this trial of any differences for any variable between normal day and short day overwinter stock. The other differences were with multipot stock and bareroot stock. On the Gurney site, multipot stock had significantly poorer CAHI than medium bareroot stock ($p = 0.02$) by 5 cm and was poorer than all bareroot stock by 6 cm. On the McArthur site, multipot CAHI were better than medium bareroot CAHI ($p = 0.003$) by 9 cm, and better than all bareroot stock by 7 cm. The best CAHI was 32 cm for multipot stock on the McArthur site and the poorest was 10 cm for multipot stock on the Gurney site.

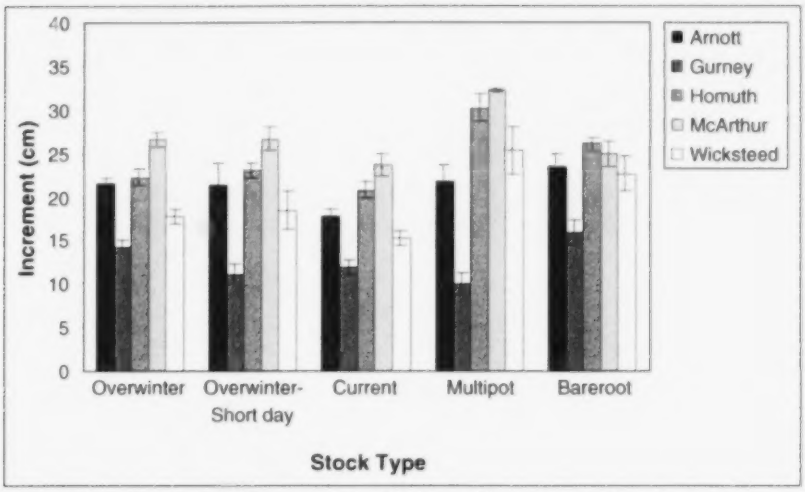

Figure 52. 1988 Black Spruce Seventh-Year Measurements – Current Annual Height Increment.

Survival was variable for all stock types on all sites. All stock types achieved the minimum of 85 percent on the Homuth site, but not by most stock types on the other sites (Figure 53). Minimum survival was achieved by overwinter-short day stock on the Wicksteed site, by multipot stock on the Wicksteed, Arnott and McArthur sites, and by bareroot stock on the Wicksteed site. The only significant differences between stock type were with overwinter stock having better survival than current stock ($p < 0.05$) on the Wicksteed and Gurney sites (range of eight to 15 percent); and with better survival of bareroot stock compared to current stock ($p = 0.001$) by 16 percent on the Wicksteed site. Survival did not differ between stock types on the other sites. The best survival was 97 percent for multipot stock on the Homuth site, and the poorest survival rate was 56 percent for current stock on the Gurney site.

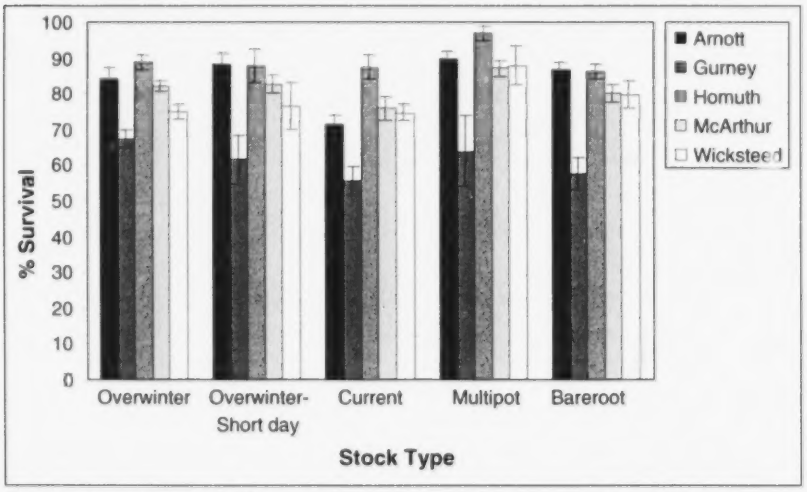

Figure 53. 1988 Black Spruce Seventh-Year Measurements – Percent Survival.

Most of the mortality had occurred on these sites by the fifth year. At least 80 percent of the cumulative mortality had occurred by this time on the Homuth, Arnott and Wicksteed sites for most of the stock types. The exception was with multipot stock, with 63 percent of the cumulative mortality on the Homuth site, and with 45 percent of the cumulative mortality on the Wicksteed site having occurred by year five. At the Gurney site, at least 90 percent of the cumulative mortality occurred by year five (Figure 54). On the McArthur site, more mortality occurred after year five compared to the other sites and mortality varied by stock type.

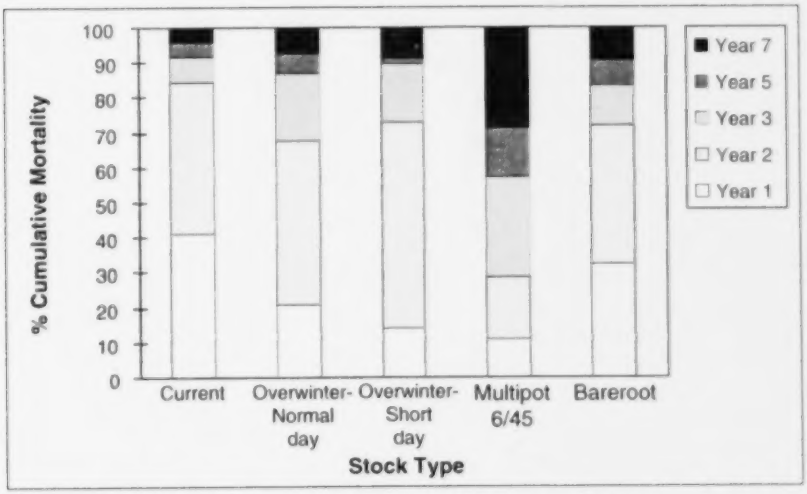

Figure 54. 1988 Black Spruce Cumulative Mortality – Gurney.

Current stock had poorer performance indexes than most stock types (Figure 55). Bareroot stock had better performance indexes than current stock on all sites ($p < 0.05$). Overwinter stock outperformed current stock on all sites except the Homuth site. Bareroot stock had a better performance index ($p < 0.001$) than overwinter stock on the Arnott site only. Multipot outperformed medium bareroot and all bareroot stock on the Homuth, Arnott and McArthur sites ($p < 0.05$). The best performance index was 146 cm for multipot stock on the Homuth site, and the poorest performance index was 38 cm for current stock on the Gurney site.

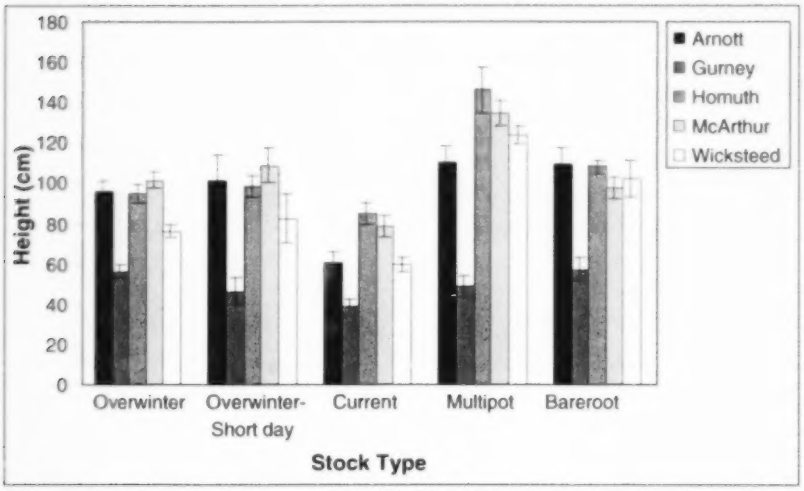

Figure 55. 1988 Black Spruce Seventh-Year Measurements - Performance Index.

Bareroot stock had significantly better relative growth rates than overwinter stock and overwinter stock had significantly better relative growth rates than current stock on almost all sites ($p < 0.05$, Figure 56). The only exception was that bareroot and overwinter stock relative growth rates were similar on the McArthur site. Multipot stock relative growth rates were significantly higher than that of medium bareroot and all bareroot stock on the Homuth and McArthur sites, but not on the other sites.

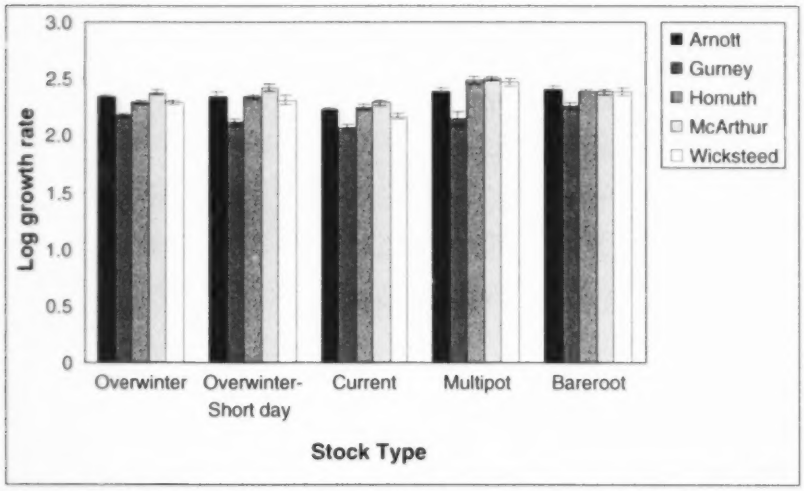

Figure 56. 1988 Black Spruce Seventh-Year Measurements – Relative Growth Rate.

Four trials were established this year in three districts: Mewhinney Township (5f), Cochrane District; Township 233 (9r) and Lessard Township (7c), Hearst District and Shackleton Township (7f), Kapuskasing District. This year was the only time that jiffypot containers were used for black spruce in these trials. In the context of this report, unlike jack pine, we are treating jiffypots as a stock type rather than a container type. We should note that the jiffypot seedlings were current seedlings.

Height growth was variable between the different sites, similar to other years (Figure 57). The hardwood ecosite trials had good growth and the black spruce-fine soil ecosite trial had poor growth. The best growth was 151 cm for multipot stock on the Shackleton site, and the shortest seedlings were 54 cm jiffypot seedlings on the Mewhinney site. Bareroot reached the minimum free-to-grow height on all sites. Free-to-grow heights were reached by the other stock types on the Lessard and Shackleton sites. The only other two stock types that reached free-to-grow were overwinter-short day and multipot stock on Township 233.

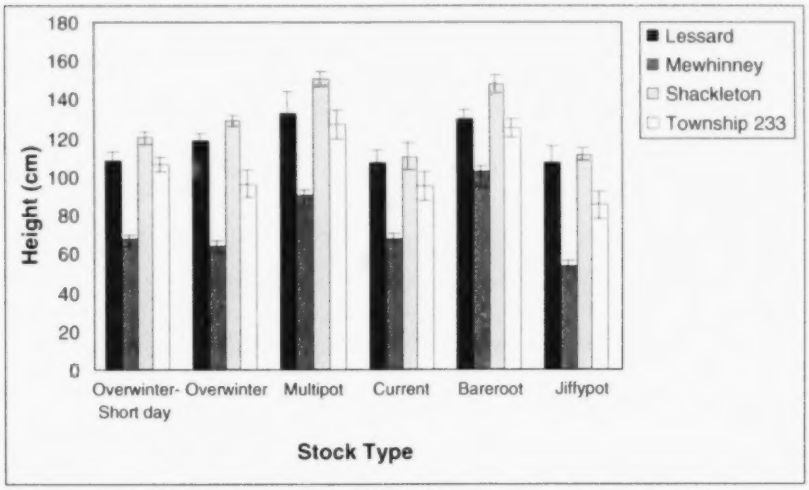

Figure 57. 1989 Black Spruce Seventh-Year Measurements – Height.

There were fewer significant differences between stock types for this year compared to the 1988 trials. Bareroot stock had significantly better height growth than overwinter stock ($p < 0.05$) on the Mewhinney and Shackleton sites. Overwinter stock had significantly better height growth than current stock on the Shackleton site. Bareroot had significantly better height growth than current stock on all sites except the Township 233 site. The only other two differences were with overwinter-normal day stock having better height growth than overwinter-short day stock on the Shackleton site, and better height growth of medium bareroot compared to multipot stock (24.9 cm difference, $p < 0.05$). No other differences were noted between stock types.

Growth rates were similar to other series (Figure 58). Some sites (e.g. Mewhinney Twp) did not have as pronounced and exponential increase after year three compared to other sites.

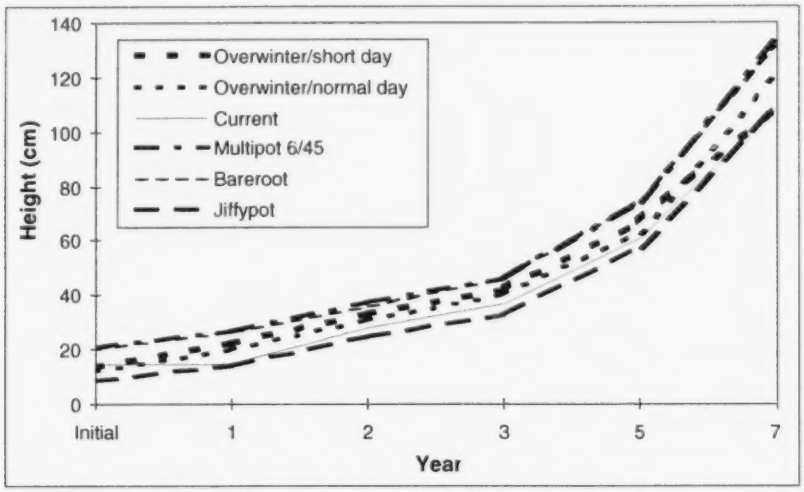

Figure 58. 1989 Black Spruce Annual Height Growth – Lessard.

Diameter differences reflected height differences in most cases (Figure 59). No differences between stock types were found on the Lessard Township site. On the other sites, bareroot diameters were significantly greater ($p < 0.05$) than overwinter stock. Bareroot also had significantly greater diameters than current stock ($p < 0.05$) on the Township 233 and Shackleton sites. Multipot stock had significantly smaller diameters than medium bareroot and all bareroot stock ($p < 0.05$) on the Mewhinney site. Overwinter stock had significantly larger diameters ($p < 0.05$) than current stock on the same site. The other difference was with overwinter-normal day stock having significantly larger diameters than overwinter-short day stock on the Shackleton site. The smallest diameters were 11 mm for jiffypot stock on the Mewhinney site and the largest diameters were 22 mm for multipot stock on the Township 233 site. Bareroot and multipot stock tended to have the larger diameters of the stock types tested.

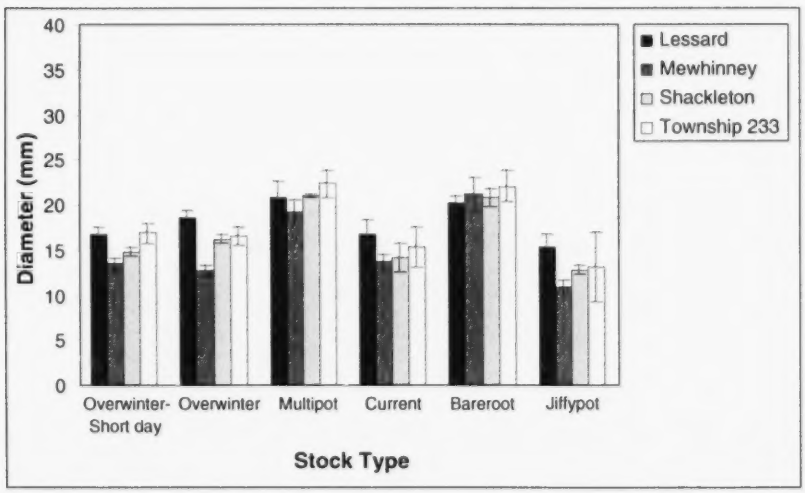

Figure 59. 1989 Black Spruce Seventh-Year Measurements – Diameter.

Current annual height increment did not differ between stock types on the Township 233, Lessard and Shackleton sites (Figure 60). On the Mewhinney site, bareroot had significantly better CAHI than overwinter stock ($p < 0.05$), multipot stock ($p = 0.026$) and current stock ($p < 0.05$). Overwinter stock was similar to current stock ($p > 0.05$). The lowest CAHI was 12 cm for jiffypot stock on the Mewhinney site, and the best CAHI was 29 cm for multipot stock on the Lessard Township site.

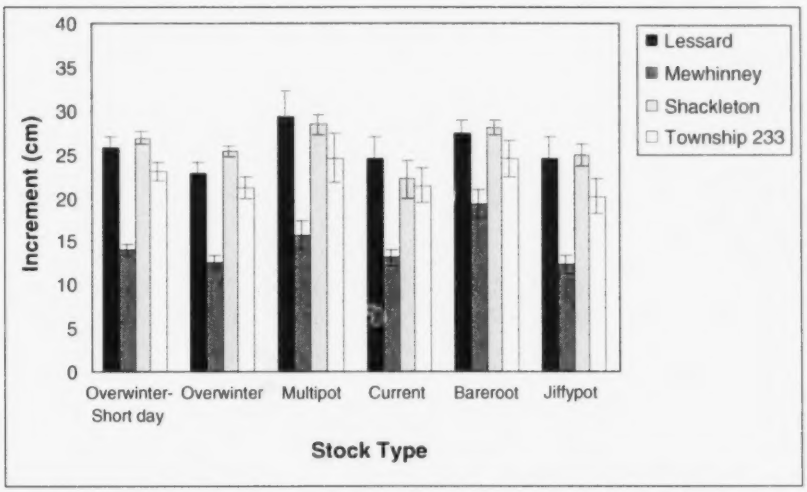

Figure 60. 1989 Black Spruce Seventh-Year Measurements – Current Annual Height Increment.

Survival was quite variable across the range of sites and stock types (Figure 61). The best survival was 98 percent for jiffypot stock on the Shackleton site, and the poorest was 40 percent for current stock on the Township 233 site. On the Township 233 site none of the stock types achieved the minimum survival rate. All of the stock types reached the minimum survival rate on the Lessard and Shackleton sites except for jiffypot stock on the Lessard site. On the Mewhinney site the overwinter and jiffypot stock did not reach the minimum percent survival, but the other stock types did reach the minimum. No significant differences were found between stock types for three of the four sites. The Township 233 site had two significant differences: overwinter stock had better survival than current stock ($p < 0.001$), and medium bareroot had better survival than multipot stock ($p = 0.03$).

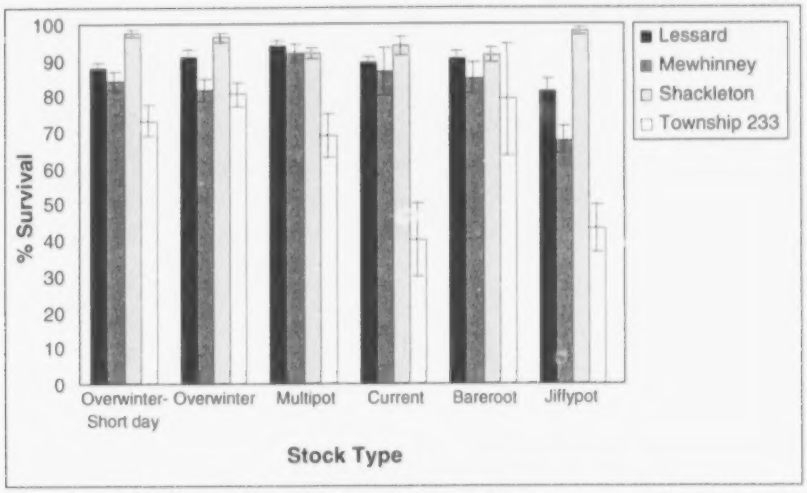

Figure 61. 1989 Black Spruce Seventh-Year Measurements – Percent Survival.

Cumulative mortality was variable for this series. The Hearst sites had at least 65 percent of the mortality occurring by year five, and even up to 100 percent for multipot stock. The Mewhinney site had 45 to 55 percent of the mortality by year five, but the Shackleton site had more variability, with 43 to 83 percent of the mortality by year five, depending on the stock type (Figure 62).

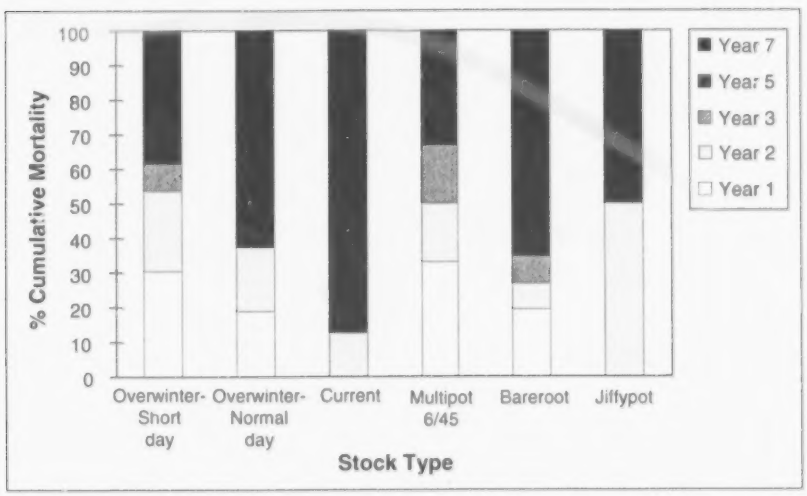

Figure 62. 1989 Black Spruce Cumulative Mortality – Shackleton.

Performance indexes had few significant differences between stock types (Figure 63). Bareroot stock had a significantly higher performance index than current stock on all of the sites ($p < 0.05$). The only other significant difference was for the Mewhinney site, where bareroot stock had a better performance index than overwinter stock ($p = 0.016$). The best performance index was 138 cm for multipot stock on the Shackleton site, and the poorest performance was 34 cm for jiffypot stock on the Mewhinney site.

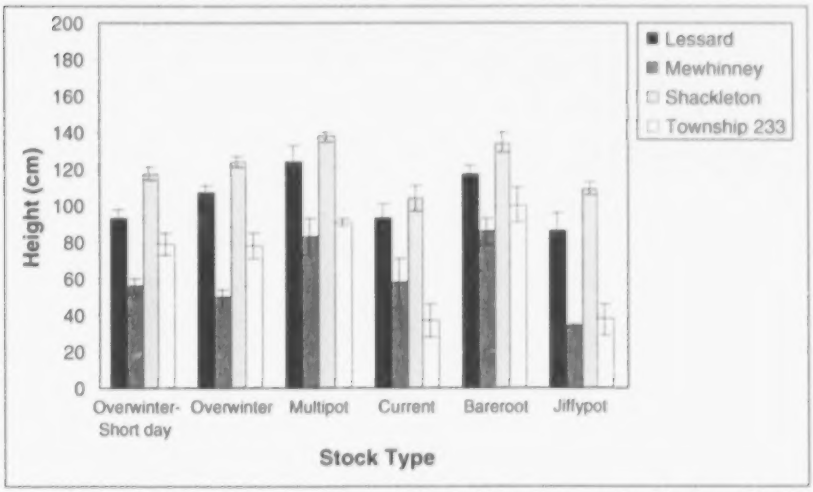

Figure 63. 1989 Black Spruce Seventh-Year Measurements – Performance Index.

Relative growth rates had few significant differences between stock types as well (Figure 64). The Township 233 site had no differences. Bareroot stock had better relative growth rates than overwinter stock on the Lessard and Shackleton sites. Bareroot stock also had better relative growth rates than current stock on the Mewhinney and Shackleton sites. The only other significance difference was for Mewhinney, where medium bareroot stock was better than multipot stock ($p = 0.025$).

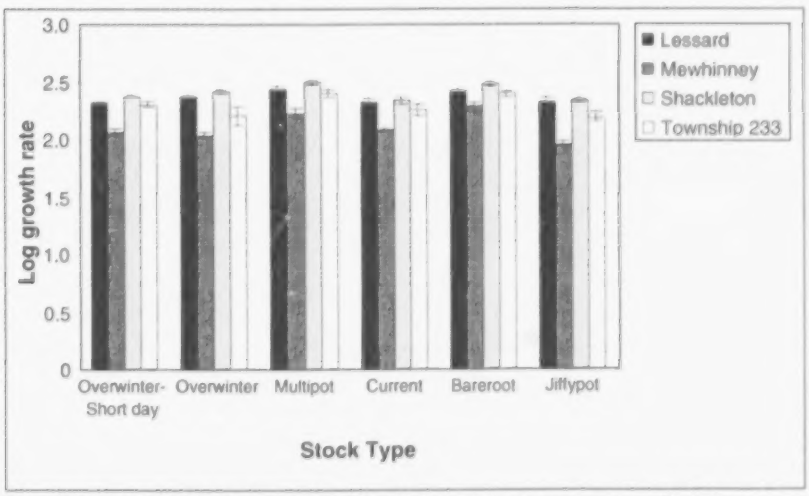

Figure 64. 1989 Black Spruce Seventh-Year Measurements – Relative Growth Rate.

Four trials were established in 1990: Blount Township (8), Cochrane District; Elgie Township (6f), Hearst District; Nansen Township (7f), Kapuskasing District and Little Township (4) in Timmins District.

Height growth was good for the 1990 trials (Figure 65). All stock types reached free-to-grow status except for current stock on the Little trial and all of the stock types on the Blount site. Bareroot stock was significantly better than current and overwinter stock on all four sites ($p < 0.001$). Overwinter stock was significantly better than current stock on the Little and Elgie sites ($p \leq 0.005$) but not on the others. Growing regime did not affect growth on most sites, but it did on the Elgie site, where short day stock were taller than normal day ($p < 0.05$). Medium bareroot was better than multipot stock on the Nansen and Little sites ($p \leq 0.046$), but was not different on the other two sites. Multipot stock did not differ in height from all bareroot stock types ($p > 0.05$). The poorest growth was 75 cm for current-overwinter stock on the Blount site. The best growth was 180 cm for multipot stock on the Elgie site.

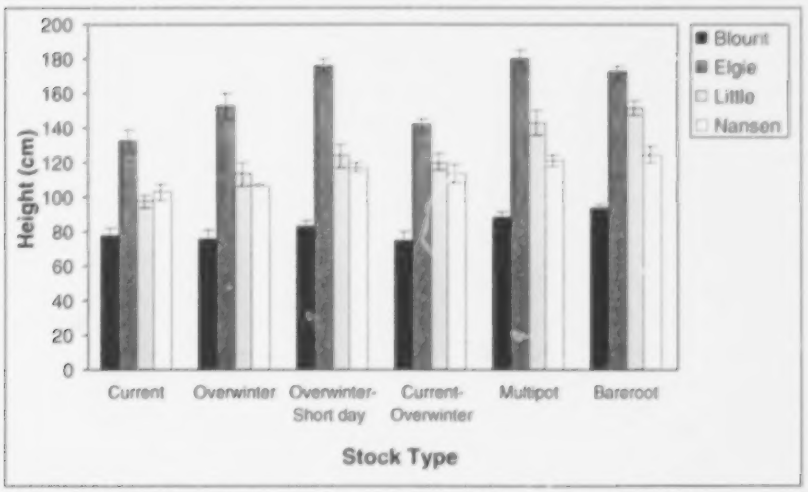

Figure 65. 1990 Black Spruce Seventh-Year Measurements – Height.

All stock types had the same growth pattern as in previous series (Figure 66). Growth during the first three years of the establishment phase was constant. Growth in the last four years was much greater than in the first three years, and in some cases was even greater after year five compared to the previous two years.

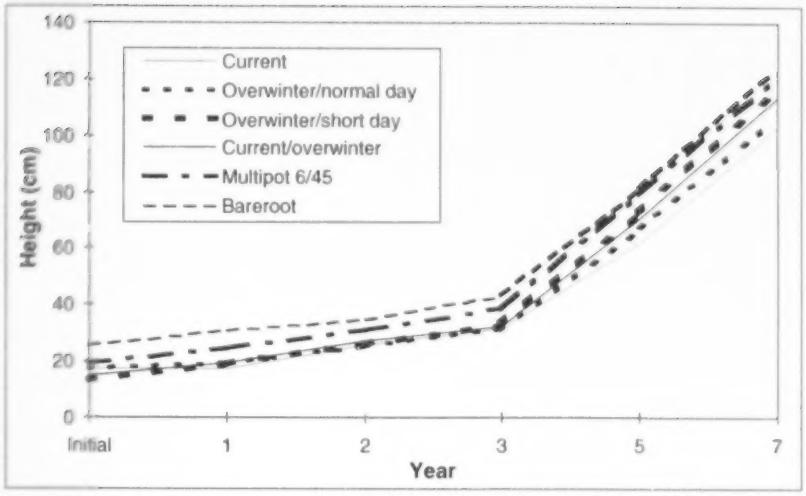

Figure 66. 1990 Black Spruce Annual Height Growth – Nansen.

Diameters reflected heights quite closely for significant differences (Figure 67). Diameters of bareroot stock were significantly greater than for overwinter stock ($p \leq 0.014$) and also for current stock ($p \leq 0.001$) on all four sites. Overwinter stock diameters were significantly greater than current stock on the Elgie ($p = 0.004$) and Little sites ($p = 0.001$), but did not differ on the other sites. Medium bareroot stock diameters were greater than multipot on the Nansen site ($p = 0.03$) and did not differ on the other sites. The minimum diameter for this series was 8 mm for current/overwinter stock in the Blount trial. The largest diameter was 29 mm for multipot stock in Elgie and for bareroot stock in Little.

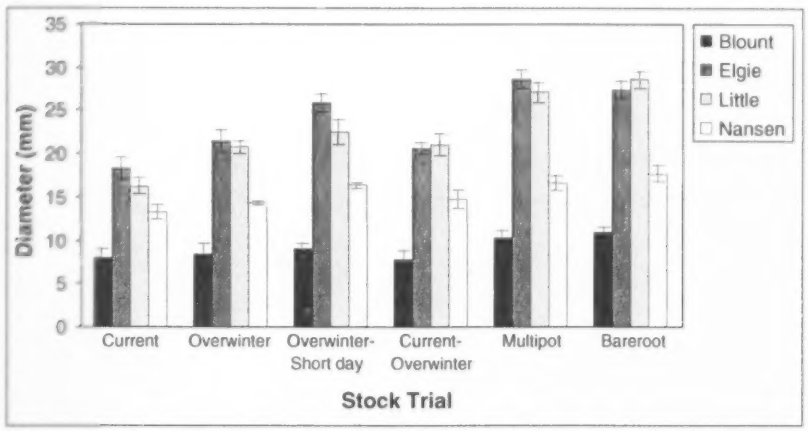

Figure 67. 1990 Black Spruce Seventh-Year Measurements – Diameter.

Current annual height increment was similar between stock types by year seven (Figure 68). Only two significant differences were found between stock types. Bareroot stock had significantly greater CAHI than current stock ($p < 0.05$) on the Little site. Bareroot CAHI was significantly greater than overwinter CAHI ($p < 0.05$) at the Blount site ($p = 0.008$). The greatest CAHI was 31 cm/yr for both overwinter-short day and multipot stock on the Elgie site. The least CAHI was 13 cm/yr for overwinter-normal day stock on the Blount site.

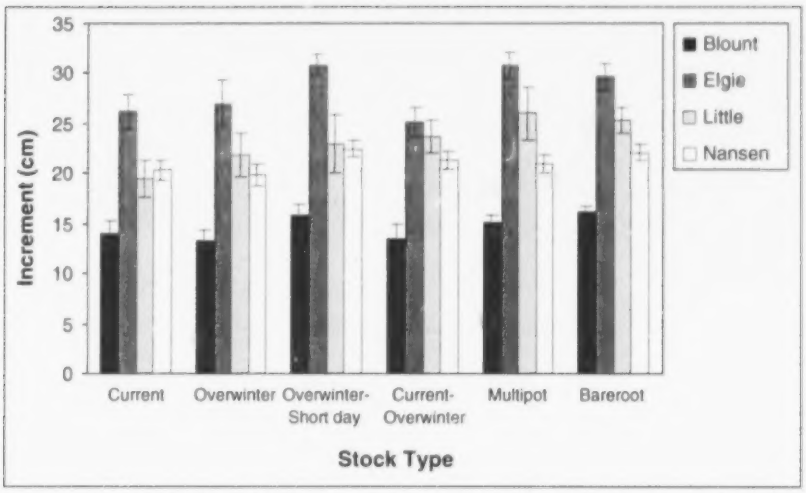

Figure 68. 1990 Black Spruce Seventh-Year Measurements – Current Annual Height Increment.

In contrast to the 1989 trials, most of the stock types did not reach the 85 percent minimum survival requirement (Figure 69). The stock types and sites that did reach this limit were both the current and overwinter-short day stock on the Blount and Elgie sites, and current-overwinter stock on the Little site. Survival rates in most comparisons were not significantly different between stock types on the four trials. Multipot stock had better survival than bareroot stock ($p = 0.018$), and short day had better survival than normal day ($p = 0.02$) on the Nansen site. Bareroot had significantly poorer survival than overwinter ($p \leq 0.039$) and current stock ($p \leq 0.0.7$) for the Nansen and Elgie sites. The poorest survival was 60 percent for bareroot on the Nansen site, and the best was 90 percent for current-overwinter stock on the Little site.

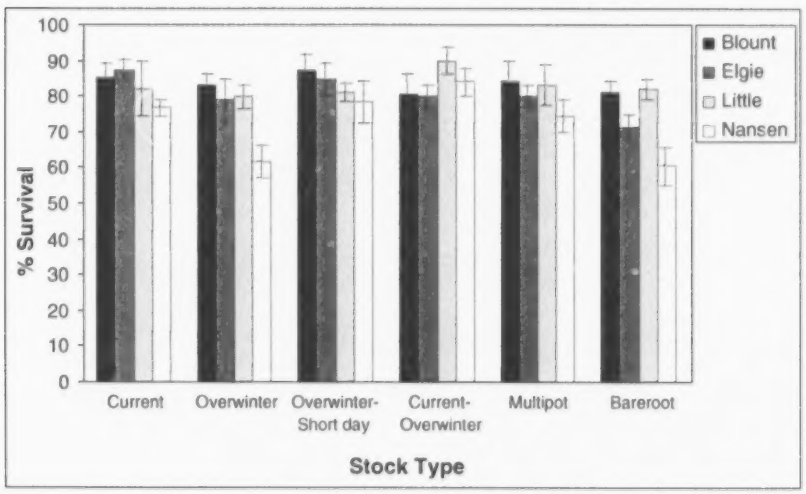

Figure 69. 1990 Black Spruce Seventh-Year Measurements – Percent Survival.

Mortality was not as consistent as in previous series. By year five cumulative mortality ranged from 20 to 65 percent for most stock types on these sites. The only exceptions were with overwinter-normal day and current-overwinter stock on the Nansen site, where 80 percent of the cumulative mortality had occurred by year five (Figure 70). It is not known why the higher mortality occurred in these trials after the initial establishment phase.

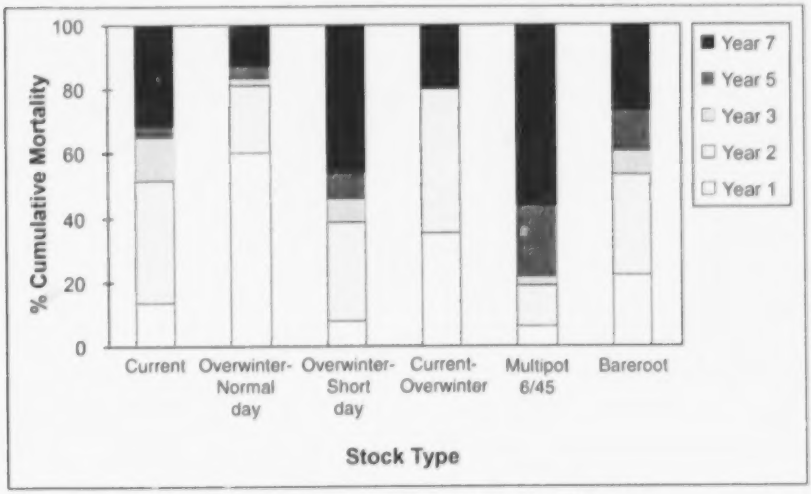

Figure 70. 1990 Black Spruce Cumulative Mortality – Nansen.

Performance indexes usually reflected height differences (Figure 71). Bareroot had significantly higher performance indexes than overwinter ($p \leq 0.02$) and current ($p \leq 0.029$) stock on the Blount and Little sites. Overwinter-short day stock had significantly better performance indexes than overwinter-normal day stock on the Nansen ($p = 0.01$) and Elgie sites ($p = 0.019$). Multipot stock outperformed bareroot stock on the Elgie site ($p = 0.035$) but did not differ on the other sites. No other significant differences were found. The best performance index was 149 cm for overwinter-short day stock on the Elgie site and the poorest performance index was 62 cm for overwinter-normal day stock on the Blount site.

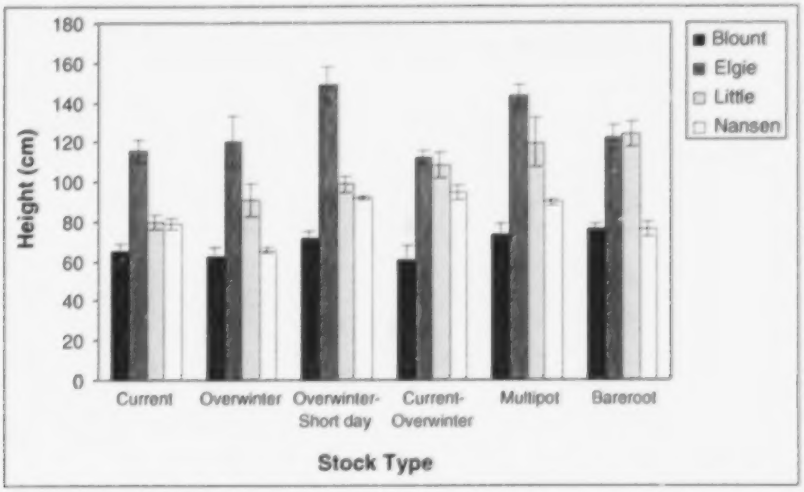

Figure 71. 1990 Black Spruce Seventh-Year Measurements – Performance Index.

Relative growth rates of bareroot stock were significantly better than that of current stock ($p \leq 0.002$) for all sites, and overwinter stock ($p < 0.001$) for all sites except the Elgie site (no difference, Figure 72). Overwinter stock had significantly higher relative growth rates than current stock, on the Elgie and Little sites ($p < 0.001$). Short day stock had significantly better relative growth rates than normal day stock on the Elgie site. No other significant differences were noted between stock types.

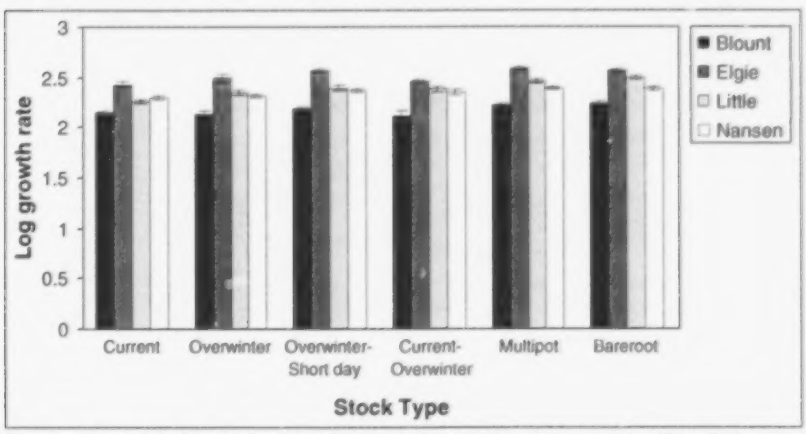

Figure 72. 1990 Black Spruce Seventh-Year Measurements – Relative Growth Rate.

Four sites were established this year: Homuth Township (8), Cochrane District; Elgie Township (6f), Hearst District; Sulman Township (12), Kapuskasing District and Macklem Township (6f), Timmins District.

Minimum free-to-grow heights were achieved by all of the stock types in these trials (Figure 73). Bareroot stock (all types) usually had the best height growth for all stock types. It was significantly better than overwinter, current and multipot stock (both types) for the Sulman and Macklem sites. Medium bareroot was significantly better than the two-year multipot stock ($p < 0.05$) on these two sites. On the Homuth site bareroot (all types) were better than overwinter stock ($p = 0.001$). Current stock was usually the same size as overwinter stock, and normal day was similar to short day stock on three of the sites ($p > 0.05$). On the Sulman site, overwinter-short day stock (mean height = 134 cm) was significantly better than current stock (mean height = 108 cm, $p = 0.05$) and was taller than normal day stock (mean height = 106 cm, $p < 0.001$). No other significant differences were found with other comparisons, and none were found for the Elgie site. The best height growth was 181 cm for bareroot stock on the Elgie site, and the poorest was 103 cm for current stock on the Homuth site.

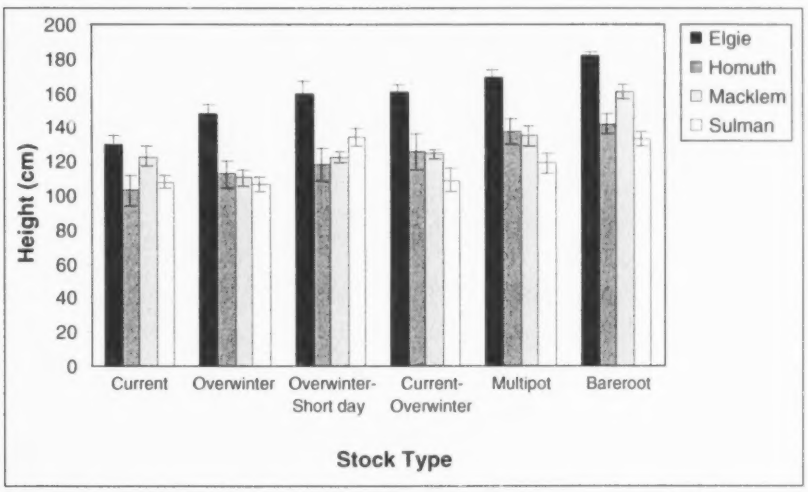

Figure 73. 1991 Black Spruce Seventh-Year Measurements – Height.

Growth trends were similar to previous series, with an establishment phase during the first three years and an exponential increase for the last four years (Figure 74). The only exception was on the Sulman site. Mean heights of bareroot stock decreased by 5 cm between years one and two. This could be attributed to frost damage in year two. Decreases in growth rates after year five for several stock types could be due to competition from shrubs (the shrubs may have been mainly in the plots with bareroot or overwinter-short day stock).

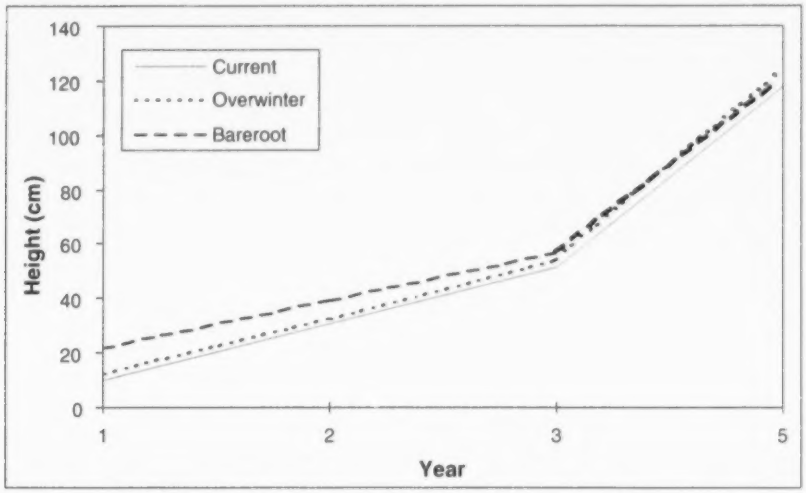

Figure 74. 1991 Black Spruce Annual Height Growth – Elgie.

Diameter growth had similar trends to height growth (Figure 75). Bareroot stock diameters were significantly better than diameters of current, overwinter and all multipot stock types on the Elgie, Sulman and Macklem sites ($p < 0.05$). Medium bareroot was better than two-year multipot stock on these same three sites ($p < 0.05$). On the Homuth site bareroot was significantly greater in diameter than overwinter and current stock ($p < 0.05$) only. None of the other stock type comparisons had significant differences on the Homuth site. Day length generally did not influence diameter growth. Only the Sulman site had overwinter-short day stock diameters significantly greater than overwinter-normal day stock diameters ($p = 0.008$). Current and overwinter stock had similar diameters on all sites except the Elgie site, where overwinter stock had significantly greater diameters (mean diameter = 21 mm) than current stock (mean diameter = 19 mm, $p < 0.001$). The largest diameter seedlings were bareroot seedlings (mean diameter = 32 mm) at the Elgie site, and the smallest diameter seedlings were current seedlings (mean diameter = 12 mm) at the Sulman site.

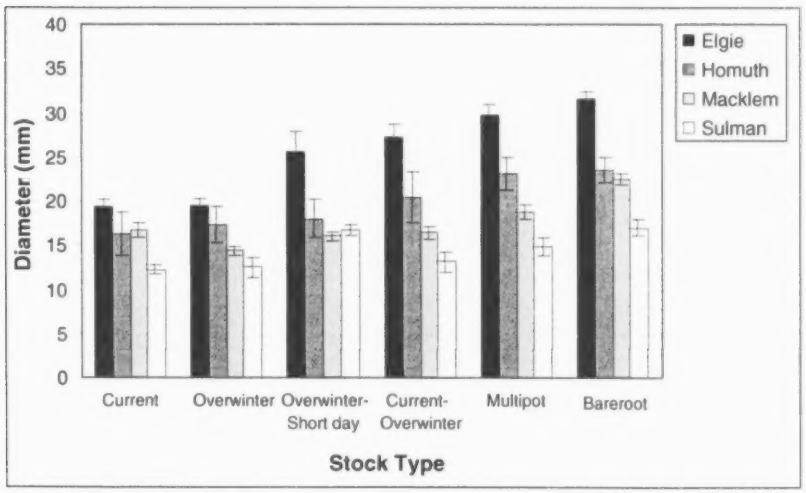

Figure 75. 1991 Black Spruce Seventh-Year Measurements – Diameter.

Current annual height increment was generally similar between stock types on the Homuth and Sulman sites (Figure 76). On the other two sites, bareroot stock had better CAHI than current and overwinter stock ($p < 0.05$). Bareroot stock (medium bareroot and all bareroot) had significantly better CAHI than multipot stock (both types) on the Macklem site only ($p < 0.05$). Current stock had similar CAHI to overwinter stock, and normal day overwinter had similar CAHI to overwinter-short day stock on all four sites ($p > 0.05$). The best increment was 32 cm/yr for bareroot stock at the Elgie site. The least increment was 18 cm/yr for current-overwinter stock on the Sulman site.

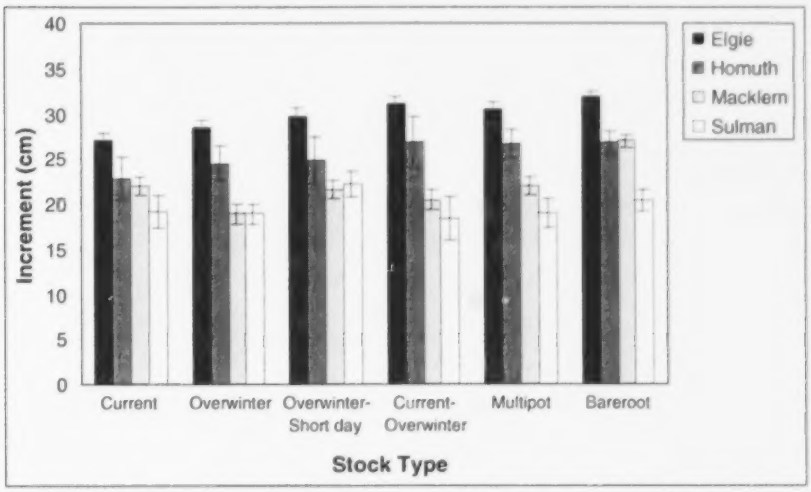

Figure 76. 1991 Black Spruce Seventh-Year Measurements – Current Annual Height Increment.

Survival was generally good for most stock types in this series (Figure 77). Over half of the stock type–site combinations achieved the minimum survival of 85 percent. As in previous series, not all of the stock types were consistent between sites. On the Macklem site, all of the stock types were over the minimum survival rate, and we found no significant differences in stock type comparisons. On this site we had the best survival for this series with 98 percent survival for multipot stock. On the Sulman site, overwinter-normal day, current-overwinter, and bareroot stock achieved the minimum percentage. Bareroot stock had the poorest survival on this site (mean = 79 percent), significantly poorer than two-year multipot (mean = 87 percent, $p = 0.049$); all multipot stock (mean = 90 percent, $p = 0.002$); and overwinter stock (mean = 86 percent, $p = 0.03$). On the Elgie site, the current, current-overwinter and multipot stock reached the minimum survival rate. Two-year multipot stock had the best survival on this site (mean = 93 percent), significantly greater than medium bareroot (mean = 78 percent, $p = 0.01$) and all bareroot (mean = 80 percent, $p = 0.007$). Combined multipot stock (mean = 91 percent) had significantly better survival than bareroot (mean = 80 percent, $p = 0.004$). On the Homuth site, current stock had the poorest survival of this series (mean = 66 percent), significantly less than overwinter stock (mean = 87 percent, $p < 0.001$) and bareroot stock (mean = 88 percent, $p < 0.001$). Multipot (mean = 84 percent) and current-overwinter stock (mean = 82 percent) survival was just below the minimum rate. We had no other significant differences with the other stock type comparisons.

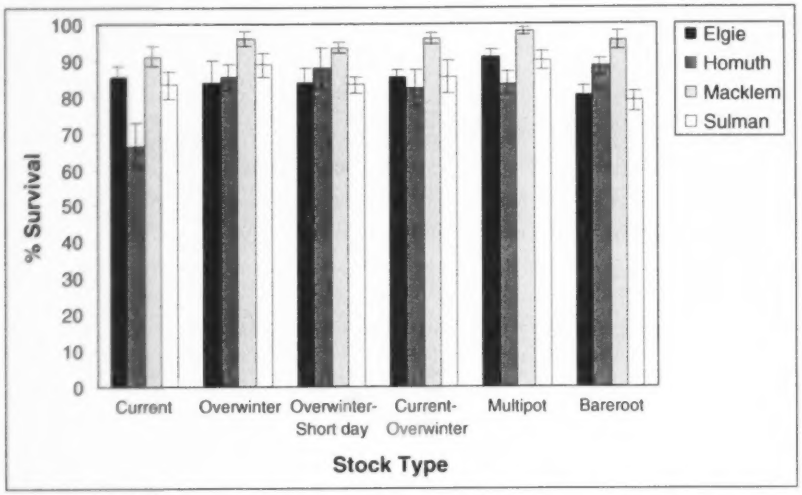

Figure 77. 1991 Black Spruce Seventh-Year Measurements – Percent Survival.

The majority of stock types had at least 70 percent of the cumulative mortality occurring by year five in this series (Figure 78). The only exceptions were on the Sulman site for multipot stock (55 percent) and overwinter-short day stock (60 percent).

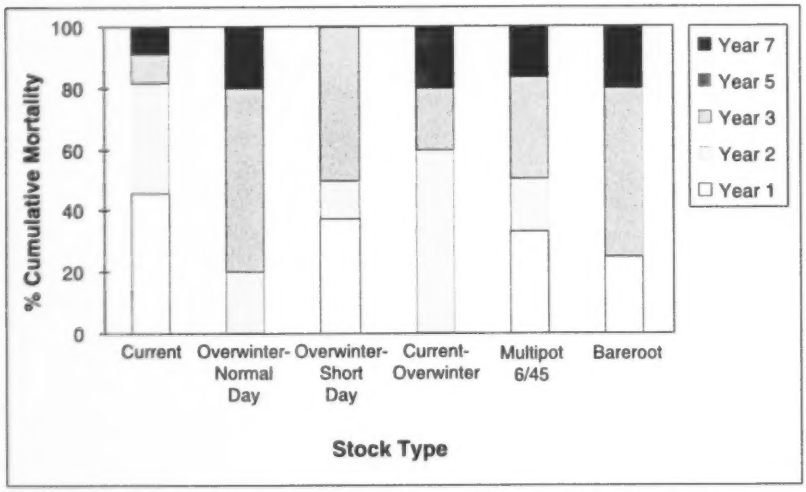

Figure 78. 1991 Black Spruce Cumulative Mortality – Macklem.

Seedling performance index comparisons were not consistent across the four sites (Figure 79). No comparisons were significantly different on the Sulman site. On the other three sites, bareroot had a significantly higher performance index than overwinter stock ($p \leq 0.009$) and current stock ($p < 0.001$). On the Homuth and Elgie sites, the performance indices of overwinter stock were significantly better ($p \leq 0.047$) than for current stock. The only other two significant comparisons were on the Macklem site. Bareroot stock on this site had a significantly better performance index than two-year multipot stock ($p = 0.038$) and all multipot ($p = 0.002$) stock. The highest performance index was 154 cm for multipot stock on the Elgie site, and the poorest performance index was 68 cm for current stock on the Homuth site.

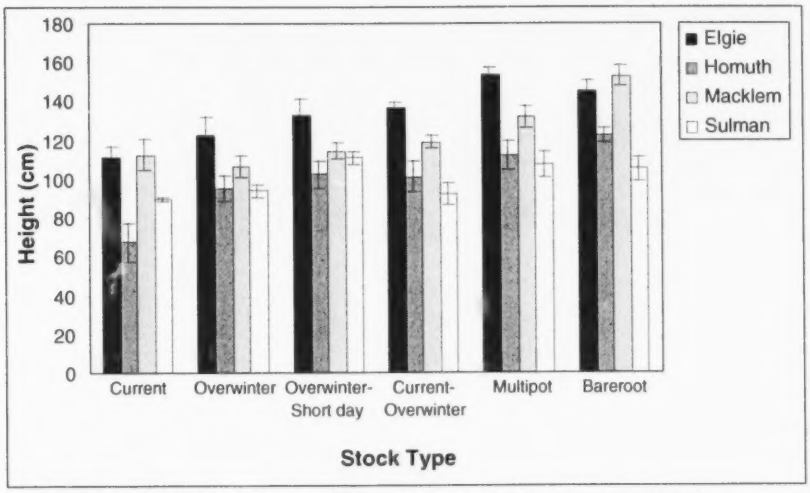

Figure 79. 1991 Black Spruce Seventh-Year Measurements – Performance Index.

Relative growth rates of bareroot stock were significantly better than of overwinter ($p \leq 0.008$) and current ($p < 0.001$) stock on all sites (Figure 80). Medium bareroot and all bareroot had significantly better relative growth rates than two-year multipot stock ($p \leq 0.025$) and all multipot stock ($p \leq 0.003$) on all sites except the Homuth site (which had no differences). Short day was significantly better than overwinter-normal day stock ($p \leq 0.01$) on the Elgie and Sulman sites. Current stock usually had similar relative growth rates to overwinter stock, with the exception of the Elgie trial. On this site, overwinter stock had better relative growth rates than current stock.

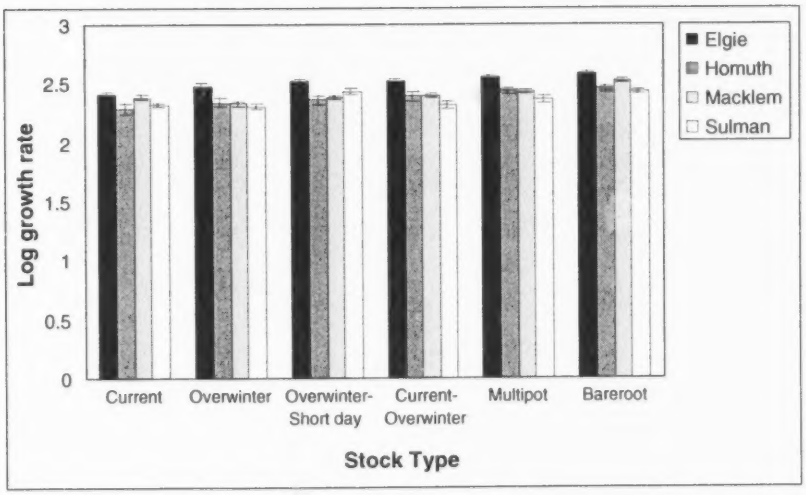

Figure 80. 1991 Black Spruce Seventh-Year Measurements – Relative Growth Rate.

General Trends – Jack Pine

Jack pine stock types used in these trials include bareroot (eight trials), overwinter and current stock (19 trials). The 1991 Elgie trial that was damaged by herbicide spray is not included in this summary. Two container types were also tested: jiffypots and 408 paperpots (six trials).

Pot type did not consistently influence any of the growth variables measured in this study. There were only two (out of six) trials where paperpots were significantly better than jiffypots for height, diameter and relative growth rates. Performance indexes were significantly better for paperpots in only one trial. The opposite was true (jiffypots significantly better than paperpots) for CAHI in one trial. The general conclusion was that pot type does not exert a major effect on seedling growth and survival during the first five years after outplanting. However, other research (Sundström 1992) has found that paperpots cause root deformation and hence their use has since been discontinued.

Bareroot seedlings (eight trials) were superior to current container stock for height, diameter and relative growth rates (seven trials) and also for CAHI and performance indexes (five trials). The trend was not as apparent for survival, as bareroot was better than current stock for two trials, yet the opposite was true for three trials.

Bareroot stock was significantly better than overwinter stock for height (four trials), diameter, performance index and CAHI (one trial), survival (two trials) and relative growth rates (three trials). However, survival of overwinter stock was significantly better than bareroot stock for one trial and in two trials for performance index. While bareroot stock performance was frequently equal to or better than overwinter stock performance, it is no longer produced in Ontario.

Overwinter and current stock were contrasted in all trials. In most cases, overwinter outperformed current stock for height and relative growth rates (11 trials), for diameter and CAHI (nine trials) and performance index (eight trials). These stock types have similar survival rates. Overwinter stock survival was significantly better than current stock in only three trials.

Given these trends we would recommend using overwinter stock for optimal seedling growth, especially on productive or competitive sites. Larger seedlings would be more desirable for these sites as they are better competitors than smaller seedlings and can reach free-to-grow status faster.

General Trends – Black Spruce

More stock types were used in the black spruce compared to the jack pine trials. Results clearly indicated that some stock types performed better than others in terms of survival and growth.

With overwinter container stock, two growing regimes were tested: short- and normal-day. The general trend across the twenty trials is that the growing regime does not appear to affect seedling growth. Where significant differences were found, normal-day had better height, diameter (two trials) and CAHI (one trial) than short-day stock. The opposite trend was true (short-day significantly better than normal-day) for survival (one trial), performance index (two trials) and relative growth rate (three trials).

Current stock was usually the poorest performer of all stock types for several variables. It was outperformed by bareroot stock for height (18 trials), diameter (14 trials), CAHI (8 trials), performance index (13 trials), and relative growth rates (15 trials). There were no clear trends for survival between bareroot and current stock. In one trial, bareroot had better survival than current and in two trials the opposite was true.

Current stock was generally outperformed by overwinter stock, but not by a large margin. Less than half of the trials demonstrated significantly better growth of overwinter stock compared to current stock. Overwinter stock was better than current stock for height (eight trials), diameter (nine trials), CAHI (three trials), survival (four trials), performance index (six trials), and relative growth rates (seven trials). There was only one case where current was significantly better than overwinter stock, and that was for survival.

Bareroot was generally better than overwinter stock for most variables. It was significantly better for height (nine trials), diameter and relative growth rates (13 trials). There was not as strong a difference for performance index (seven trials) and CAHI (four trials). No differences were usually detected for survival, but in three trials overwinter stock was significantly better than bareroot.

Two-year multipot stock was usually similar to bareroot stock in most trials (17 in all). Where significant differences were found, there were no consistent trends. Multipot seedlings were significantly better than medium bareroot seedlings for height and diameter growth (four trials), CAHI and survival (one trial), performance index (three trials) and relative growth rates (two trials). Medium bareroot were better than multipot seedlings for height and CAHI (three trials), diameter and relative growth rates (four trials) and survival (one trial).

Discussion

What Stock Types Reach Free-to-Grow Status in Five Years for Jack Pine?

No single stock type consistently reached one metre tall at five years for all of the trials. However, the majority of the stock types did reach one metre in height. Current stock in 79 percent of the trials (15/19) reached free-to-grow at five years. Overwinter stock reached free-to-grow in 84 percent (16/19) of the trials, and bareroot reached free-to-grow in 75 percent (6/8) of the trials. The last two series tested pot type (in addition to stock type) and this variable did not appear to have an influence on height growth, as all six trials reached free-to- grow for these two pot types.

No single stock type consistently achieved the minimum standard of 90 percent survival. Both container stock types, current and overwinter, reached this level in 14 out of 19 trials (74 percent). Bareroot stock only reached the minimum of 90 percent survival in four out of eight trials, or 50 percent of the time. Jiffypots reached the minimum survival standard in three out of six trials (50 percent) and paperpots were slightly better, with four out of six trials. It would appear that overwinter stock is the most suitable for reaching minimum standards for survival and height growth. Although bareroot stock usually has better height growth than current stock, this benefit is frequently offset by lower survival rates.

What Stock Types Reach Free-to-Grow Status in Seven Years for Black Spruce?

Results are not as clear for black spruce stock types as for jack pine. Bareroot stock had the greatest chance of reaching free-to-grow status at seven years in 18 out of the 20 trials (90 percent). Current-overwinter stock reached free-to-grow in seven out of eight trials (87 percent). Overwinter stock types, both normal day and short day growing regimes, reached free-to-grow in 16 trials (80 percent). Multipot stock reached free-to-grow in 14 trials (70 percent). Current stock reached free-to-grow in only 11 trials (55 percent). Jiffypot stock (also a current stock) had the poorest growth, reaching free-to-grow in only two out of four trials and were the shortest compared to the other stock types on these two sites.

Survival was poorer for black spruce than jack pine. Most stock types on most trials did not reach the minimum of 90 percent survival requirement. These results strongly suggest that additional monitoring may be necessary when establishing black spruce plantations. The best survival was with multipot stock, reaching the minimum requirement in ten trials (59 percent). Current-overwinter stock reached this minimum in four out of eight trials (50 percent). Current stock was third, with minimum survival reached in eight trials (40 percent). Bareroot and overwinter-short day stock only reached the minimum survival in just over one-third of the trials (35 percent), and overwinter-normal day stock was slightly poorer than this (30 percent). Jiffypot had the poorest survival, reaching the minimum survival rate in only one trial (25 percent).

The most desirable black spruce stock type for survival and height growth would be two-year multipot stock, having both good height growth and high survival. Bareroot and overwinter-short day stock would be next for desirability with respect to survival and height growth.

Advantages of Larger Stock

The larger seedlings used in this trial, such as the bareroot and multipot stock, have similar height growth. They usually outperformed the smaller stock types, especially the current stock. These larger seedlings are better for more competitive sites, and will outperform smaller stock (Hellum 1976, Hahn and Smith 1983). Larger seedlings will retain their initial height advantage for several years after planting (Alm 1983, Ball and Kolabinski 1986), and this advantage is not dependent on the stock type (Arnott 1975, Dobbs 1976, Duddles and Owston 1990). Large container stock will grow as well as bareroot stock of similar size, and will not differ in height after several years.

Survival did not differ between the larger stock types in most of the trials. The infrequency of significant contrasts would suggest that significant differences were due to chance, site conditions, stock handling or stock problems that may not have been immediately obvious. While the literature suggests that container stock usually has better survival than bareroot stock (Hite 1974, Hay and Keegan 1982, Hahn and Hutchison 1978, Wood and Jeglum 1984), the opposite was true in another (Helgerson *et al.* 1989).

Relative growth rates for container seedlings have been found to be better than for bareroot (Hay and Rennie 1983). However, in this study, there were no clear trends for this variable.

Smaller container stock are attractive to resource managers because of the relatively cheaper cost of production, quick turn around and availability. However, managers need to consider the site and whether the stock is suitable for the site. Smaller stock are suitable for poorer sites with less competition (Ball and Kolabinski 1986). However, as was clearly demonstrated in this trial series, if smaller stock are used on more competitive sites, they will be outperformed by the larger stock. The initial savings may be lost in higher tending costs, replanting or delayed regeneration of the site and a delay in reaching free-to-grow status.

Advantages of a Long-Term Trial Series

These trials help to emphasize a number of factors to consider when setting up an experiment of this nature. First of all, the project demonstrates the importance of having trials established on different sites and different years, having more than one trial established, and more than one or two seasons of assessments. Most of the trials had significant differences between stock types at years one and two. By year five for jack pine and year seven for black spruce, few of these differences remained. This study clearly demonstrates that seedlings need three years to get established on a site, regardless of stock type. After this establishment phase, growth rates increased. We also observed an improvement in stock quality over time, as shown by better height growth for plots installed at the end of the trial, compared to plots installed at the start of the trial for the same stock type.

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Appendix 1. List of Stock Type Identification by Grower, Year of Sowing, Seed Zone, Age/Size, Container Type and Growing Regime. Tables are Separated by Species and Trial Establishment Year.

Appendix 1a. Grower Identification Codes.

Grower	Code
Aidie Creek Growers	ACG
Birchill	BHN
Blazecka	BLZ
Chapleau Nursery	CHA
Energreen Enterprises	ENG
Gogama Nursery	GOG
La Maison Verte	LMV
Lafleur	LAF
Lava Mountain	LMT
Mark Kean Resources	MKR
Millson Forestry (Timmins)	MFT
Millson Forestry (Val Gagné)	MFV
North Shore Nursery	NSN
Northern Greenhouse Farms	NGF
North Gro	NGD
Swastika Tree Nursery	SWA
Thessalon Tree Nursery	TSN

Appendix 1b. Codes Used in Age/Size Description.

Code	Description
C + 1 (OW)	Coldframe and overwinter
C/OW	Current/overwinter
CURR	Current
G	Greenhouse sown
OW	Overwinter
OW-S.D.	Overwinter - short day
1.5	Number of years in a seedbed or transplant bed

Appendix 1c. Jack Pine Stock Types Used in 1987.

Stock Number	I.D. Number	Age/Size	Container/Bareroot	Growing Regime
1	ACG86 4200	OW	FH 408 paperpot	
2	BLZ86 3200	OW	FH 408 paperpot	
3	ENG86 3200	OW	FH 408 paperpot	
4	ENG86 4200	OW	FH 408 paperpot	
5	Not planted			
6	LAF86 4200	OW	FH 408 paperpot	
7	MFV86 3200	OW	FH 408 paperpot	
8	NGF86 3200	OW	FH 408 paperpot	
9	NGF86 4200	OW	FH 408 paperpot	
10	MKR86 3200	OW	FH 408 paperpot	
11	ENG87 3200	CURR	FH 408 paperpot	
12	ENG87 4200	CURR	FH 408 paperpot	
13	LAF87 3200	CURR	FH 408 paperpot	
14	MFV87 3200	CURR	FH 408 paperpot	
15	NGF87 4200	CURR	FH 408 paperpot	
16	LMV87 3200	CURR	FH 408 paperpot	
17	GOG 2+0 3200	2 year	Bareroot	
18	GOG 2+0 4200	2 year	Bareroot	
19	CHA 2+0 3200	2 year	Bareroot	
20	CHA 2+0 4200	2 year	Bareroot	

Appendix 1d. Jack Pine Stock Types Used in 1988.

Stock Number	I.D. Number	Age/Size	Container/Bareroot	Growing Regime
1	ACG87 4200	OW	FH 408 paperpot	
2	NGD87 4200	OW	FH 408 paperpot	
3	ENG87 3200	OW	FH 408 paperpot	
4	ENG87 4200	OW	FH 408 paperpot	
5	NSN87 4200	OW	FH 408 paperpot	
6	LAF87 4200	OW	FH 408 paperpot	
7	MFV87 3200	OW	FH 408 paperpot	
8	LAF87 3200	OW	FH 408 paperpot	
9	NGF87 4200	OW	FH 408 paperpot	
10	MKR87 3200	OW	FH 408 paperpot	
11	ENG88 3200	CURR	FH 408 paperpot	
12	ENG88 4200	CURR	FH 408 paperpot	
13	LAF88 3200	CURR	FH 408 paperpot	
14	MFV88 3200	CURR	FH 408 paperpot	
15	NGF88 3200	CURR	FH 408 paperpot	
16	LMV88 3200	CURR	FH 408 paperpot	
17	GOG 2+0 3200	2 year	Bareroot	
18	GOG 2+0 4200	2 year	Bareroot	
19	CHA 2+0 3200	2 year	Bareroot	
20	CHA 2+0 4200	2 year	Bareroot	

Appendix 1e. Jack Pine Stock Types Used in 1989.

Stock Number	I.D. Number	Age/Size	Container/Bareroot	Growing Regime
1	ACG88D 342-36	OW	FH 408 paperpot	
2	NGF88D 132-32-0-00	OW	FH 408 paperpot	
3	LAF88D 432-31-0-00	OW	FH 408 paperpot	
4	ENG88D 342-36-0-00	OW	FH 408 paperpot	
5	LMV88D 032-34	OW	FH 408 paperpot	
6	LAF88D 442-31-0-00	OW	FH 408 paperpot	
7	MFT88D 042-31	OW	FH 408 paperpot	
8	ENG89B 042-31	CURR	FH 408 paperpot	
9	MFV89B 042-33	CURR	FH 408 paperpot	
10	LMV89B 032-34	CURR	FH 408 paperpot	

Appendix 1f. Jack Pine Stock Types Used in 1990.

Stock Number	I.D. Number	Age/Size	Container/Bareroot	Growing Regime
1	NGF90H432-32-0-00	CURR	Jiffypot 165	Double crop
2	MFT90B032-31-0-00	CURR	Jiffypot 165	Double crop
3	LAF90B432-36-0-00	CURR	FH 408 paperpot	Double crop
4	LMV90B032-34-0-00	CURR	FH 408 paperpot	Double crop
5	NGF89Q432-34-0-00	OW	Jiffypot 165	Double crop
6	LAF89Q432-38-0-00	OW	Jiffypot 165	Double crop
7	LMT89D532-36-0-00	OW	FH 408 paperpot	Double crop
8	LAF89D432-31-0-00	OW	FH 408 paperpot	Double crop

Appendix 1g. Jack Pine Stock Types Used in 1991.

Stock Number	I.D. Number	Age/Size	Container/Bareroot	Growing Regime
1	ENG91B842-36-0-00J6	CURR	Jiffypot 165	Double crop
2	NGF91B842-36-0-21J6	CURR	Jiffypot 165	Double crop
3	LAF91B032-31-3-81P4	CURR	FH 408 paperpot	Double crop
4	LMT91B032-34-0-00P4	CURR	FH 408 paperpot	Double crop
5	NGF90D742-31-0-00J6	OW	Jiffypot 165	Double crop
6	MFT90D032-38-0-00J6	OW	Jiffypot 165	Double crop
7	LAF90D442-32-0-00P4	OW	FH 408 paperpot	Double crop
8	ENG90D532-31-0-00P4	OW	FH 408 paperpot	Double crop

Appendix 1h. Black Spruce Stock Types Used in 1987.

Stock Number	I.D. Number	Age/Size	Container/Bareroot	Growing Regime
1	ACG 86C 32-35	OW	FH 408 paperpot	Single crop
2	BHN 86C 32-32	OW	FH 408 paperpot	Single crop
3	NGD 86C 32-32	OW-S.D.	FH 408 paperpot	
4	ENG 86C 32-35	OW	FH 408 paperpot	Double crop
5	LAF 86C 32-38	OW	FH 408 paperpot	Double crop
6	LMT 86C 32-32	OW	FH 408 paperpot	Double crop
7	MFV 86C 32-35	OW	FH 408 paperpot	
8	NGF 86C 32-35	OW	FH 408 paperpot	Double crop
9	NGD 86C 32-32	OW	FH 408 paperpot	
10	LMV 86C 32-34	OW	FH 408 paperpot	
11	TSN 86C 32-32	OW-S.D.	FH 408 paperpot	
12	ENG 87D 32-36	CURR	FH 408 paperpot	Double crop
13	LAF 87D 32-32	CURR	FH 408 paperpot	Double crop
14	LMT 87D 32-36	CURR	FH 408 paperpot	Double crop
15	Not available			
16	NGF 87D 32-32	CURR	FH 408 paperpot	
17	LMV 87D 32-34	CURR	FH 408 paperpot	
18	STN 32-34	1.5 + 1.5	Small bareroot	
19	STN 32-35	G + 1.5	Medium bareroot	

Appendix 1i. Black Spruce Stock Types Used in 1988.

Stock Number	I.D. Number	Age/Size	Container/Bareroot	Growing Regime
1	ACG 87C 32-35	OW	FH 408 paperpot	Single crop
2	BHN 87C 32-32	OW	FH 408 paperpot	
3	NGD 87C 32-32	OW-S.D.	FH 408 paperpot	
4	ENG 87C 32-35	OW	FH 408 paperpot	
5	LAF 87C 32-38	OW	FH 408 paperpot	
6	LMT 87C 32-32	OW	FH 408 paperpot	
7	MFV 87C 32-35	OW	FH 408 paperpot	
8	NGF 87C 32-35	OW	FH 408 paperpot	
9	NGD 87C 32-32	OW	FH 408 paperpot	
10	LMV 87C 32-34	OW	FH 408 paperpot	
11	BHN 87C 32-32	OW-S.D.	FH 408 paperpot	
12	ENG 88D 32-36	CURR	FH 408 paperpot	
13	LAF 88D 32-32	CURR	FH 408 paperpot	
14	LMT 88D 32-36	CURR	FH 408 paperpot	
15	STN 32-32	C + 1 (OW)	Multipot 6/45	
16	NGF 88D 32-32	CURR	FH 408 paperpot	
17	LMV 88D 32-34	CURR	FH 408 paperpot	
18	STN 32-34	1.5 + 1.5	Small bareroot	
19	STN 32-35	G + 1.5	Medium bareroot	
20	STN 32-35	G + 2	Large bareroot	

Appendix 1j. Black Spruce Stock Types Used in 1989.

Stock Number	I.D. Number	Age/Size	Container/Bareroot	Growin Regime
1	ACG 88C332-35-0-00SD	OW-S.D.	FH 408 paperpot	
2	BHN88C132-32-0-00SD	OW-S.D.	FH 408 paperpot	
3	NGD88C032-32SD	OW-S.D.	FH 408 paperpot	
4	ENG88C332-32-0-00	OW	FH 408 paperpot	
5	BLZ88C332-35-0-00	OW	FH 408 paperpot	
6	LMT88C132-32-0-00SD	OW-S.D.	FH 408 paperpot	
7	MFV88C132-34-0-00	OW	FH 408 paperpot	
8	NGF88C432-35-0-00	OW	FH 408 paperpot	
9	Not available			
10	LMV88C032-34SD	OW-S.D.	FH 408 paperpot	
11	ENG87M332-32-0-00	2 year	Multipot 6/45	
12	LMV89A032-34	CURR	FH 408 paperpot	
13	STN 1.5+1.5 32-38-0-00	3 year	Large bareroot	
14	STN G+1.5 32-32	3 year	Medium bareroot	
15	STN G+2 32-35-0-00	3 year	Small bareroot	
16	LMV88C032-34 Jiffy	OW	Jiffypot 165	

Appendix 1k. Black Spruce Stock Types Used in 1990.

Stock Number	I.D. Number	Age/Size	Container/Bareroot	Growing Regime
1	LMV90AO32-34-0-00P4	CURR	FH 408 paperpot	Double crop
2	ENG89CO32-32-0-00P4	OW	FH 408 paperpot	Double crop
3	ACG89C532-36-0-00P4	OW-S.D.	FH 408 paperpot	Single crop
4	LMT89F532-35-0-00P4	C/OW	FH 408 paperpot	Double crop
5	NGF88M132-32-0-00M5	2 year	Multipot 6/45	Double crop
6	STN87R032-34-0-00	3 year	Large bareroot	
7	STN87R032-34-0-00	3 year	Medium bareroot	
8	STN87R032-34-0-00	3 year	Small bareroot	

Appendix 1l. Black Spruce Stock Types Used in 1991.

Stock Number	I.D. Number	Age/Size	Container/Bareroot	Growing Regime
1	ENG91A832-34-0-00P4	CURR	FH 408 paperpot	Double crop
2	LAF90C432-32-0-00P4	OW	FH 408 paperpot	Double crop
3	ACG90C532-35-0-00P4	OW-S.D.	FH 408 paperpot	Single crop
4	NGF90F532-35-0-00P4	C/OW	FH 408 paperpot	Double crop
5	BHN89M032-32-0-00M5	2 year	Multipot 6/45	Double crop
6	STN88AL32-35-0-00G2	3 year	Large bareroot	
7	STN88AM32-35-0-00G5	3 year	Medium bareroot	
8	STN88AS32-35-0-00F5	3 year	Small bareroot	
9	LAF90CO32-38-0-00M5	1 year	Multipot 6/45	Double crop